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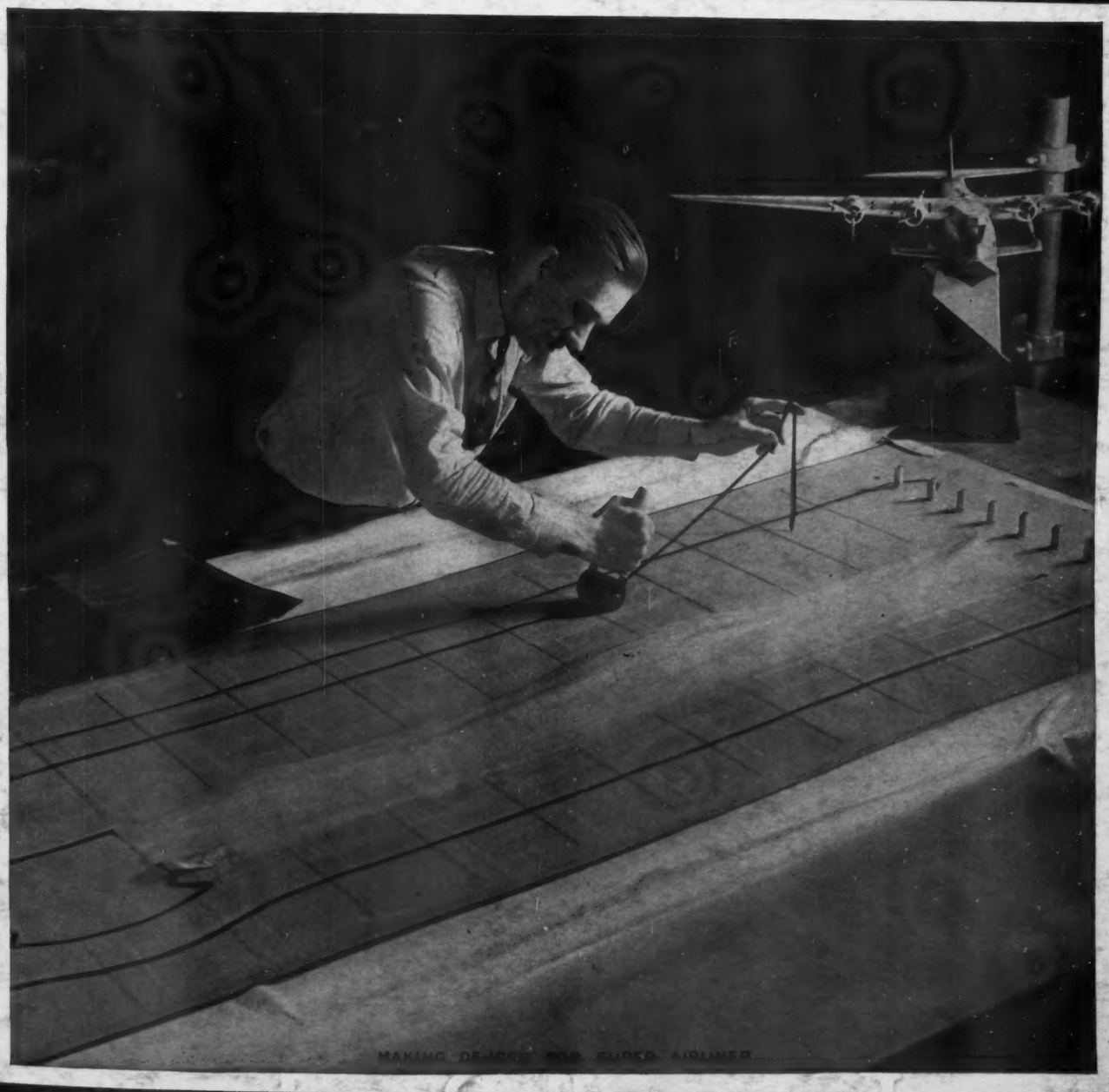

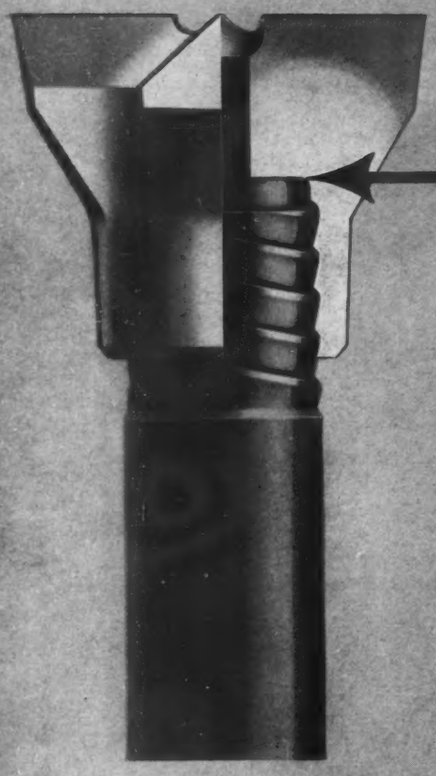

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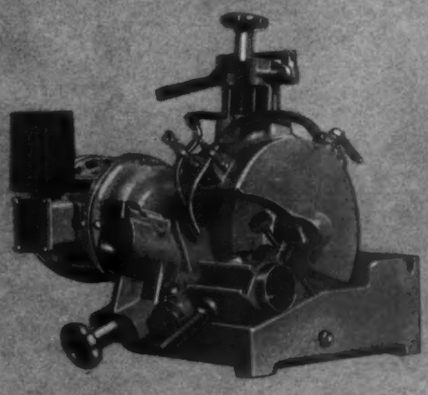

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ON THE COVER

THE photograph was taken in the plant of The B. F. Goodrich Company, Akron, Ohio, and shows one of the steps in building a section of the largest aircraft de-icers ever made. They will be installed on a 72-passenger Boeing transatlantic flying boat being manufactured for Pan American Airways. More than 310 square feet of specially processed fabric and rubber were required for them. They were made up in six sections, the longest of which measures 20 feet. To operate them, the rubber coatings are pulsated with compressed air at 7½ to 8 pounds pressure. De-icers of this sort were first used in 1930 on a Douglas biplane of the National Air Transport Company, and are now standard equipment on most of the world's airliners.

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IN THIS ISSUE

NOWADAYS, touring by automobile is a favorite way of spending a vacation. This *Wanderlust* is not surprising, in view of the fact that fine roads and highway bridges lead well-nigh everywhere and enable the public to go from place to place without delay and effort. This month another region of great scenic beauty, which heretofore could be reached only by ferries, has been made easily accessible by opening to traffic the Thousand Islands International Bridge extending across the St. Lawrence River and linking New York State with the Province of Ontario. This crossing was built jointly by United States and Canadian interests. It is 8½ miles long, and consists of a series of bridges and interconnecting viaducts and roads which are described in the leading article.

•

APPROXIMATELY 15 hp. is transmitted through the piston of a drifter drill to the drill steel. This gives a pretty good idea of the tremendous impact that takes place 1,800 or more times a minute, and indicates why rock drills must be built of the most enduring materials obtainable. An article detailing the care that one world-known manufacturer takes to procure materials that will make its drills more efficient and serviceable starts on page 5667.

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LET air hoists do the hauling, was the decision of U. S. Engineers, and, as a consequence, tugs are no longer used to pass millions of board feet of lumber through a series of locks around a stretch of falling water in the Willamette River in Oregon. The tugs had to come back empty through the locks, so much waste time and effort, while the hoists are always on the job to pull the rafts through. In addition, they help to open the lock gates. Henry W. Young tells about this substitution in an article on page 5675.

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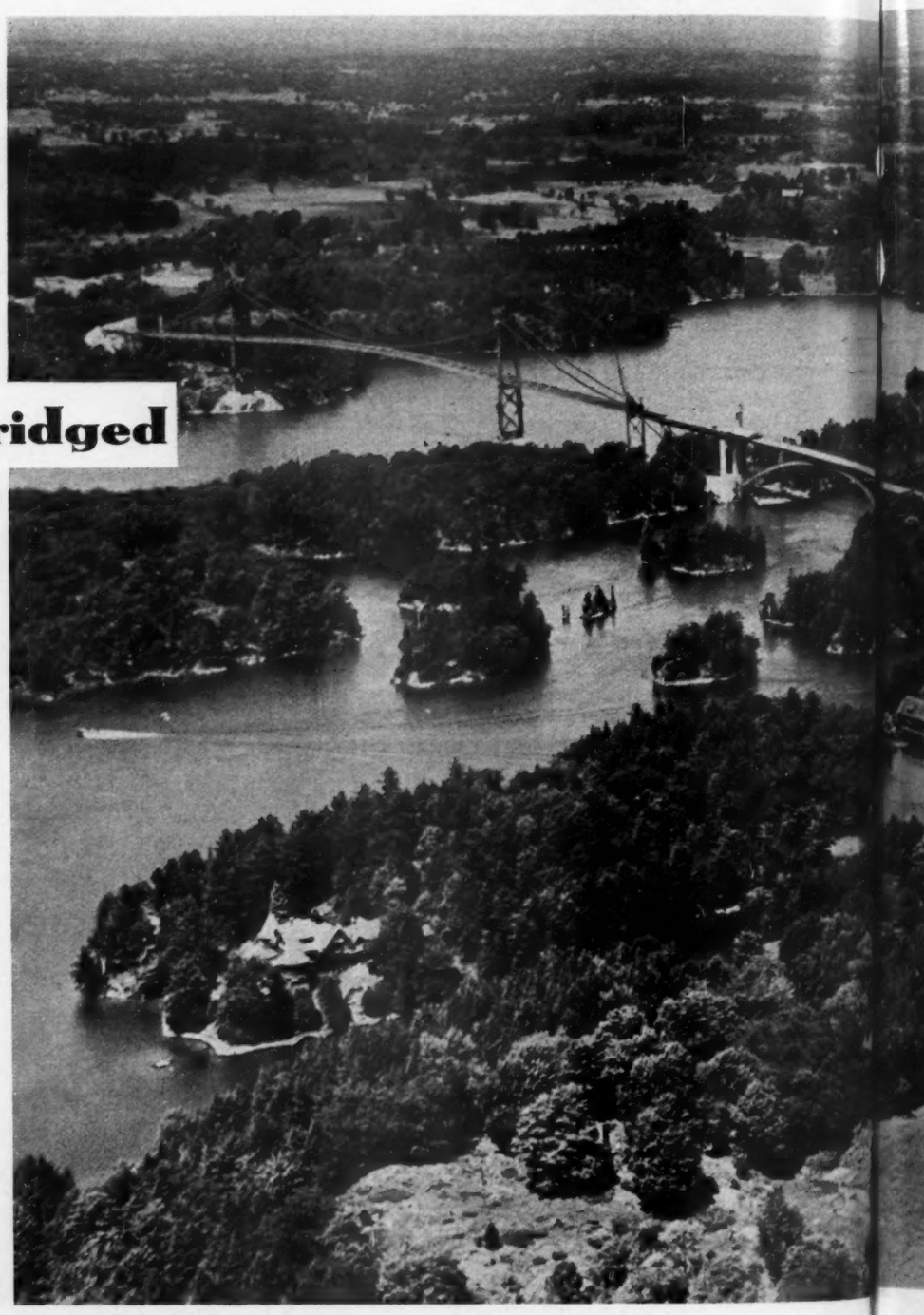


St. Lawrence Bridged

R. G. Skerrett

"THE Garden of the Great Spirit." Such is the descriptively beautiful designation our Indians of the past gave to that scenically wonderful section of the St. Lawrence River now popularly known as the Thousand Islands. Directly athwart the midlength of that 1,700-aggregation of islands, large and small, has been built and recently opened to traffic an 8½-mile crossing consisting of five diversified spans and several miles of interconnecting highway. We refer to what is officially known as the Thousand Islands International Bridge.

In this day of monster bridges, continually increasing in number, the Thousand Islands International Bridge might not immediately demand attention because of the outstanding dimensions of any of its divisional features. Nevertheless, the undertaking is a noteworthy one for three reasons: It reveals the creative skill of the bridge engineer; it gives to the motoring public a long-desired and superior means of traveling from shore to shore of the St. Lawrence at all seasons of the year; and, finally, it provides a new channel of free intercourse between two countries that have maintained cordial relations without a break for a century. This is remarkable in a world where there is and has been so much strife for decades.

To those that may have forgotten, it is a matter of historic record that groups of dissatisfied Canadians combined and rebelled against their own government 101 years ago; and the ranks of those insurgents were either swelled or otherwise helped by misguided American sympathizers. That participation threatened armed conflict between the United States and Great Britain. Happily, at that point, the President of the United States—then Martin Van Buren—issued in January of 1838 a proclamation forbidding American citizens to give material or other support to the disaffected Canadians. That stand on the part of our Government disposed of an ugly situation. Since then, Canada and the United States have been good neighbors in all that term implies. The official ceremonies at the opening of the Thousand Islands International Bridge emphasized the hundred years of peace and good will between the two countries.

The bridge is the direct response to the demands of the ever-growing automobile traffic moving annually to and from the opposite shores of the St. Lawrence River in that part of the great boundary waterway. The Thousand Islands afford summertime retreats and playgrounds for a large number of people from the two countries; and to that scenically charming region are drawn many tourists every vacation season. Heretofore, the nearest structural crossing has been the toll bridge 100 miles downstream to the eastward which spans the St. Lawrence between Cornwall, Ont., and Rooseveltown, N. Y. To the westward, the closest permanent crossing has been the International Bridge at Niagara Falls, quite 200 miles away. In the absence of such structures, various ferry lines served the area; and those boats, of differing capacities, were run only during the summer months.

The Thousand Islands International Bridge is the outcome of years of agitation for such a convenience and owes its building

Photo, Thousand Islands Bridge Authority

at Thousand Islands

THREE-SPAN CROSSING

Bird's-eye view of the picturesque Canadian channel of the St. Lawrence River showing from right to left the 2-truss bridge, the arch span, and the suspension bridge leading to Ivy Lea on the mainland of Canada. Between the arch and the suspension bridge can be seen the 3-function pier.

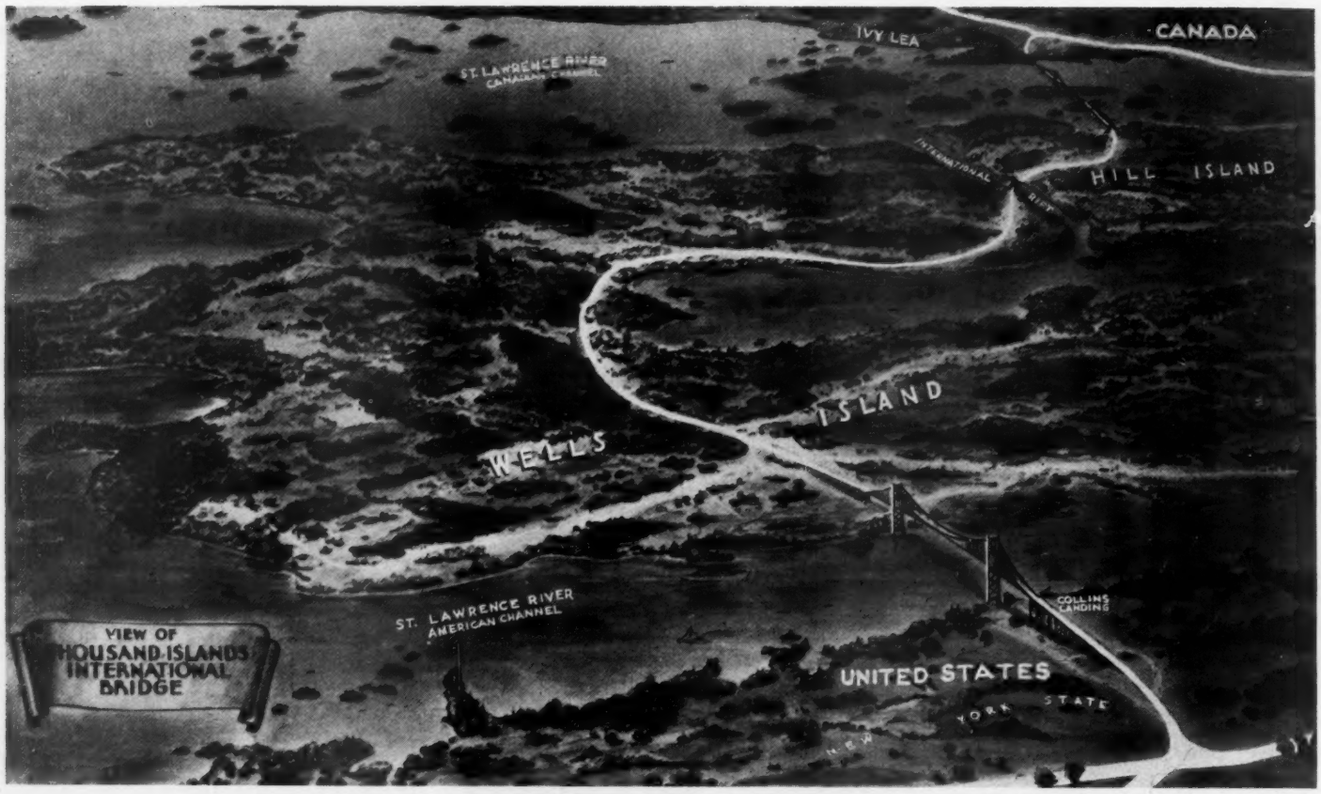
to enterprising groups of citizens in the Province of Ontario and in Jefferson County in the State of New York. The Canadians took the initiative in obtaining from the provincial government of Ontario a franchise for the Thousand Islands Bridge Company to construct its section of the international crossing; and in 1933 the Legislature of the State of New York created the Thousand Islands Bridge Authority, which, working under the joint American and Canadian rights, has directed the consummation of the project.

Operations were started on May 1, 1937, with the turning of earth, in the presence of Canadian and American dignitaries, at the boundary waterway known as the International Rift. So energetically was the work carried forward from then on that it was possible to place the bridge in service on August 18 just gone, months in advance of the contract date set for completion. According to authoritative estimates, between 500,000 and 1,000,000 vehicles will make the crossing annually; and even though the toll is lower than the charge for ferry transportation, it is expected that the income will be sufficient to pay off the bonded debt in about fifteen years. Thereafter, the bridge will be the joint property of the Province of Ontario and of Jefferson County, New York State, and will in all probability be operated as a free route.

Because of the composite character of the crossing we shall refer to it in that way rather than give the idea that it is a single bridge. To the designers, Robinson & Steinman, of New York City, the problem was not one of just providing structures long enough, wide enough, and high enough to span the several water gaps in the route between the shores of the St. Lawrence. Primarily, the cost of the project had to be kept as low as practicable while meeting the present-day standards of structural strength and ease and safety of travel; topographical advantages offered by the ground traversed had to be utilized to the fullest extent; and, finally, it was necessary to design structures of concrete and steel that would harmonize with the beautiful scenic setting. These several requirements have been successfully met—just one more evidence of the modern bridge engineer's resourcefulness which, in this case, has made it possible to build an 8½-mile crossing for the comparatively moderate outlay of $2,200,000.

The crossing starts on the American side of the St. Lawrence at Collins Landing, and has its northern terminal on the Canadian shore at Ivy Lea, Ont. Between these points, in a bee line, is a stretch of 4⅓ miles; but the actual distance as traced by the adopted route across the intervening islands is much longer because of the winding course of the intermediate highway links. To prevent confusion, we shall describe just what the driver of a motor car does in making the trip from the New York to the Ontario side of the river.

Even before the Thousand Islands International Bridge was started there was



Courtesy, Robinson & Steinman

PANORAMIC VIEW

This reproduction of a wash drawing by G. B. Dexter shows the circuitous and scenically beautiful 8½-mile route of the new Thousand Islands International Bridge. In the map at the left the heavy black line indicates the point at which it crosses the St. Lawrence River.

in service a fine road paralleling the New York waterfront between Alexandria Bay on the east and Cape Vincent on the west; and the American approach to the crossing runs off from this highway at a right angle. So headed, the driver has only a few hundred yards to go before reaching the southern viaduct. This mounts from the ground level for a length of 1,500 feet to the southern side span of the graceful suspension bridge across the American channel of the St. Lawrence. The side span is 350 feet long and adjoins the main 800-foot span that links the two high towers carrying the suspension cables. These sustain the deck at a height that assures a clearance at mean high water of 150 feet throughout the width of the deep channel that is threaded by well-nigh all the large ships plying between the Great Lakes and Montreal and thence, possibly, to the Atlantic.

On leaving the main span of this structure, the motorist runs the 350-foot length of the north side span and then descends by an easy gradient on the 1,500-foot north viaduct. This takes him to the ground level of large Wells Island and to the beginning of the new 2-lane highway built there. The latter crosses the island and extends for about 5 miles to the next water break, the International Rift, between Wells and Hill islands. It is laid out like a great letter S and skirts the western and northern shores of lovely Lake of the Isles.

The narrow and shallow International Rift is spanned by a rigid-frame, arched bridge of reinforced concrete faced with cut granite quarried from an adjacent ledge. It has a length of only 90 feet and a clearance of 15 feet at high water that affords passageway for small craft. The structure is jocularly spoken of as "The Biggest Little Bridge in the World" because of its international function. Midlength, there is embedded in the roadway a transverse strip of brass which marks the boundary line, and each side railing carries a bronze tablet inscribed to that effect.

From the International Rift the traveler follows another new 2-lane highway, approximately 2 miles long, which terminates on the northwestern flank of Hill Island. There he meets the first of the steel spans that bridge a succession of water gaps between Hill Island and the Ontario shore. Here, in the Canadian channel of the river, the engineers have utilized the lesser channel islands as stepping stones. From south to north, the three so used are: Benson, Constance, and Georgiana islands. All are largely of rocky formation.

The southernmost of the three Canadian-channel spans is 600 feet long and made up of two continuous trusses with a clearance above water of 30 feet. On leaving the northern end of this 2-span truss, the motorist goes over a 516-foot viaduct that crosses Constance Island and adjoins an artistic arch span, 368 feet in over-all length, that bridges the gap between Constance and Georgiana islands. From there the route continues over an intermediate viaduct, 205 feet long, on Georgiana Island, meeting the south side span of the fine suspension bridge that crosses the main section of the Canadian channel. The main span of this bridge is 750 feet long from center to center of the two tall and graceful towers. The northern side span, also 300 feet long, is linked by a 211-foot viaduct to a new highway that meets it well above the river on the bluff shore front of Ivy Lea. The center span has a clearance at high water of 120 feet, which is more than ample to accommodate the types of vessels that use that tortuous route.

The five bridges and their associate

AMERICAN SUSPENSION BRIDGE

Looking northward across the American channel of the St. Lawrence from Collins Landing, the southern terminal of the Thousand Islands International Bridge that was opened to traffic on the 18th of this month. The span shown here is 1,500 feet long and has a maximum clearance of 150 feet at mean high water so as not to interfere with shipping between Montreal and the Great Lakes. Both approaches are in the form of viaducts, each 1,500 feet long.

viaducts each carry a 2-lane roadway, 22 feet wide, and two 3-foot sidewalks, one on each side. On the two suspension spans, the driveway and sidewalks lie between the outlying and flanking stiffening girders which were designed to serve also as railings. Because of the low height of the latter, the motorist commands a clear and sweeping view of the surrounding scenery instead of being fenced in as is frequently the case where the dominating thought in building a bridge is to afford the shortest and quickest route between two points. The stiffening girders are interconnected by the usual floor layout of beams and stringers. The roadbed is of armored concrete; has a thickness of 4¼ inches, and is reinforced with a locked I-beam type of construction. On the viaducts, the floor beams are spaced on approximately 6½-foot centers, and they are set on the girders and are cantilevered beyond them. This arrangement resulted in a saving of steel and contributed to ease of erection. The viaduct roadways carry reinforced-concrete slabs 8 inches thick.

As explained by Dr. D. B. Steinman, "The bridge, as a whole, was designed with a view to obtaining an artistic effect in keeping with the scenic setting. The dominant features, of course, are the tall towers of the two suspension spans, together with the graceful sweep of the sustaining cables

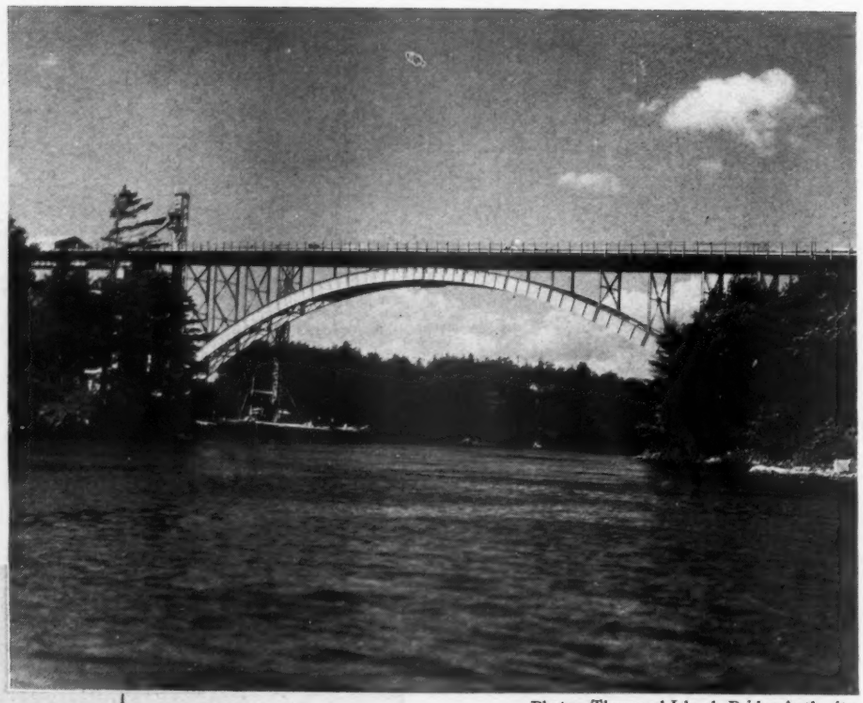
Photos, Thousand Islands Bridge Authority

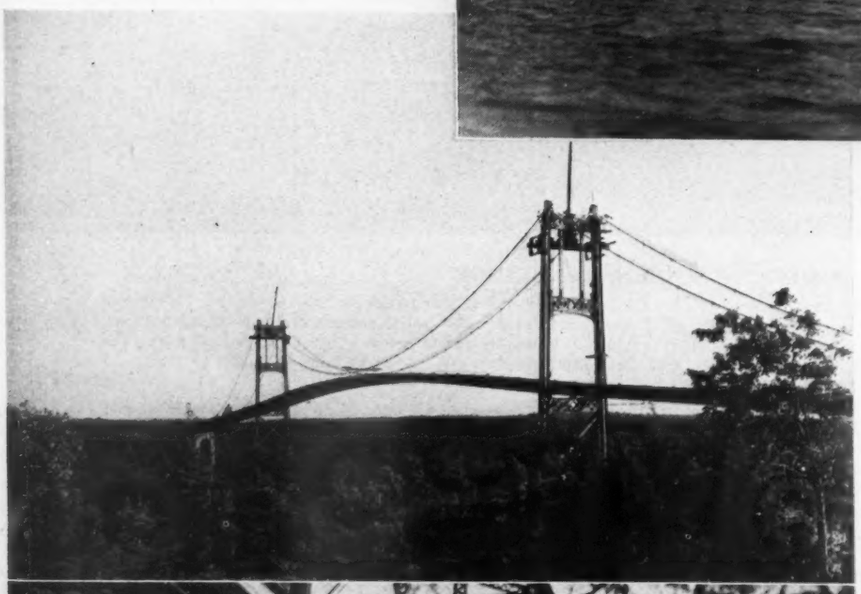
"BIGGEST LITTLE BRIDGE IN THE WORLD"

This imposing name has been jocularly given to the 90-foot-long masonry span shown here because it is an important link between Canada and the United States. It crosses what is known as the International Rift, and boasts a custom house at each end.

CANADIAN-CHANNEL SPANS

At the right is the graceful arch span across the "Lost Channel." It has an over-all length of 368 feet and connects Constance and Georgiana islands. Immediately below is the 1,350-foot-long Canadian suspension bridge shortly before its completion. The picture was taken from the bluff shore front of Ivy Lea looking south. The northern end of the continuous truss bridge that extends for a distance of 600 feet from Hill to Constance islands is shown at the bottom. In the foreground is small Benson Island on which rests the central pier of the latter structure.





Photos, Thousand Islands Bridge Authority

and the roadway line running between them. In design, the four towers, which are substantially alike, are made up of straight lines that produce a pleasing and harmonious composition, with gracefully arched portals above the roadways. The steelwork has been painted a patina green to blend still more successfully with nature's background. At the uppermost tips of each of the towers there are two aviation beacons." In the crossing of the Canadian channel, it might be added, the designers have obtained the effect of structural rhythm by interposing the sweeping arched span between the successive curves of the suspension-bridge cables and the much more conventional interlaced lines of the two trusses which link Hill and Constance islands.

Each of the steel suspension cables is composed of 37 wire-rope strands and is secured at each end to a new type of anchorage that was invented by Holton D. Robinson of the firm of Robinson & Steinman. Each cable strand is fastened by means of an interconnecting, internally and oppositely threaded steel sleeve to a corresponding threaded anchor bar that is for the most part embedded in the monolithic mass of the concrete anchorage. The projecting ends of these bolts are likewise threaded, so that the rotation of the interconnecting sleeve permits the stress or pull on each strand to be nicely adjusted. In this manner it is possible to make a symmetrical distribution of the combined load borne by the anchorage.

In most cases, rock on which to establish the anchorages and the footings of the numerous piers was found at or near the ground surface, and wagon drills and drifters on tripods were used in excavating

the various foundations. The pier for the southern tower of the Canadian suspension bridge rests on a shoal of solid rock that lies 240 feet offshore from the north side of Georgiana Island. That rock, though surrounded by deep water, rises within 17 feet of the surface of the river. A simple open cofferdam enabled the contractor to unwater the area and to prepare the rock to receive the concrete for the pier footing. The north anchorages of both suspension bridges rest on solid rock that was close to the surface of the ground and readily removed with rock drills. The south anchorage of the American suspension bridge, which is on the mainland, is supported by rock that lies from 30 to 50 feet below the ground surface. After the overburden was cleared to a depth of 15 feet, a suitable connecting underpinning was provided by driving steel piles, consisting of 14-inch, 89-pound H-beams, down to bedrock. The upper ends of these were embedded in the monolithic reinforced-concrete mass of the anchorage.

The two viaduct approaches of the American suspension bridge are carried on a succession of steel and concrete piers—every third pier being of concrete and the two succeeding ones of steel. The concrete piers take the longitudinal reaction and afford room enough for expansion rockers, while the flexible steel columns of the adjacent piers take care of expansion and contraction in the deck structure. The steel piers have rock footings to which they are tied by anchor bolts that penetrate the rock to a depth of 5 feet.

The southern anchorage for the Canadian suspension bridge is on the south side of Georgiana Island where the rock rises steeply from the water's edge and is such as to offer the necessary resistance to the horizontal pull of the suspension cables. Not only that, but the formation lends itself equally well to sustaining the horizontal thrust from the northern end of the arch that links Georgiana and Constance islands. At that point the bridge engineers, taking advantage of what nature had to offer, located a unique triple-function pier. This serves, first, as the south anchorage for the suspension bridge; second, as the north abutment for the contiguous steel arch; and, third, as the pylon that flanks the north end of that arch and affords support for the arch floor panel and the connecting viaduct span.

Work on this international crossing was variously divided. The entire project was designed by Robinson & Steinman, who served both as consulting engineers and as supervisors of construction. Monsarrat & Pratley, of Montreal, were retained as associate engineers; and William T. Field, of Watertown, N. Y., acted as advisory engineer. The principal contractors engaged on the undertaking were: the Dominion Construction Company, for the American substructures; the American Bridge Company, for the American superstructures; Cameron & Phin, for the Canadian substructures; the Canadian Bridge Company, for the Canadian superstructures; and R. A. Blyth, for the International Rift span. The subcontractor on the substructures for the American span was N. R. Corbiscello, of Binghamton, N. Y. Portable compressors, wagon drills, drifters, Jackbits, riveting hammers, impact wrenches, and other air-operated equipment were used extensively in dealing with different aspects of construction and erection and helped to bring the project to completion in substantially 15½ months.

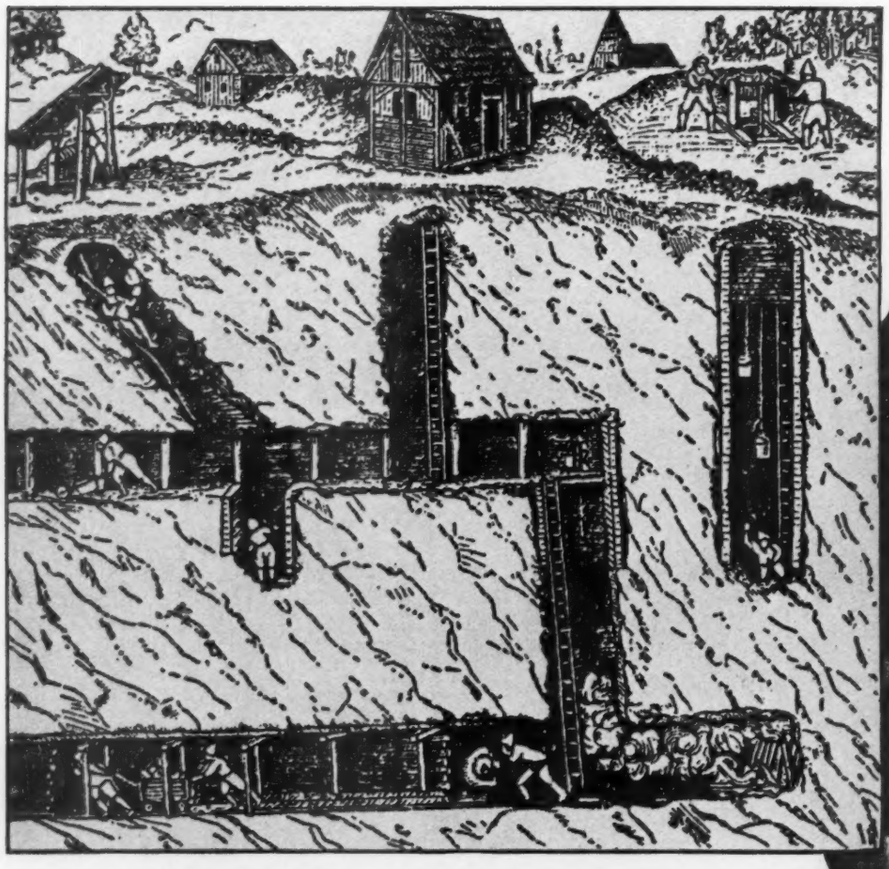
Courtesy, Robinson & Steinman

TRIPLE-FUNCTION PIER

An outcropping ledge of solid rock on the south side of Georgiana Island offers a firm footing for this unique pier which, among other things, serves as an anchorage for one bridge and an abutment for another. This picture plainly shows the new type of anchor bolt that is used for the suspension-bridge cables. The latter are made up of 37 strands, and by the new arrangement each strand is secured at both ends. In this way the load borne by the anchorage is symmetrically distributed.

The Thousand Islands Bridge Authority, which has borne the brunt of winning financial support for the crossing, will continue as the administrative body. That organization is made up of Elton H. Miller, chairman; Frank J. Martin, vice chairman; Leon Schwerzmann, secretary; Eben C. Sawyer and Ross Parker, members; William T. Field, advisory engineer; and W. Grant Mitchell, executive secretary.

This splendid crossing, besides making accessible to the motorist the diversified attractions of the State Park and other features of expansive Wells and Hill islands, is linked at its northern end with King's Highway No. 2 which runs to Toronto, Montreal, and Quebec and which has a branch at Kingston that turns northward into that fascinating region of innumerable lakes, large and small, occupying the southeastern section of the Province of Ontario. The tourist, the camper, the fisherman, the sportsman generally, and the nature-lover have ample reason to rejoice that Canada and the United States are thus brought together by a new bond that will greatly promote neighborly intercourse.



SEVENTEENTH-CENTURY MINING

An illustration from Agricola's "De re Metallica" published in 1621. The clouds in the drift at the lower right represent smoke from fire kindled at the rock face. After the rock had been thus heated it was fractured by dashing cold water against it.

MODERN DRILLING SCENE

Economy in mining depends largely upon breaking rock and ore at low cost. High-powered drifter drills, like the DA-35 shown here, make it possible to put in a round of blast holes in much less time than it used to take to drill a single hole by hand methods. The rock-drill manufacturer, by increasing the drilling speed of his product, has reduced production costs of all mining operations and has made the handling of progressively lower-grade ores profitable.

WHEN Peter Piltdown, the Pleistocene man, gouged out a new cave in which to shelter himself and his family, he was undertaking a Herculean task. A granite edifice was denied him, for with the crude tools and simple methods of excavation at his command, he necessarily had to seek a location in softer rock, such as sandstone or shale. The artifacts of Peter and other primitive men do not reveal clearly just how they managed to penetrate rock at all; but we know that the process must have consisted of a tiresome repetition of pecking away at it with perhaps a sharp-edged piece of flint or quartz. Here and there a fissure or a bedding plane provided a line of least resistance that proved of some assistance; but under even the most favorable conditions progress must have been painfully slow.

Many centuries later, around the time of the dawn of the Christian Era, even though considerable progress had been made in the meantime in the art of excavating, both methods and equipment were still woefully inadequate when viewed in the light of present facilities and knowledge. Considering how little the peoples who lived then had to help them with their work, the magnitude of some of their construction projects involving rock removal is truly amazing. The only reason they were able to do what they did was that labor was extremely plentiful and cheap. In many instances, slaves or prisoners of war were pressed into this service by the thousands, with a tragic sacrifice in human lives.

Because of the slowness with which such operations could be conducted, it was the custom of the Theban kings, immediately upon ascending the throne, to put a large force of men to work upon their burial tombs. The digging of some of these sepulchers required a tremendous amount of labor. For example, to provide a final resting place for King Mineptah at Thebes, a tunnel was driven 300 feet into a hillside and, after a shaft had been sunk to meet it, was carried 350 feet farther and there enlarged into a chamber for the sarcophagus.

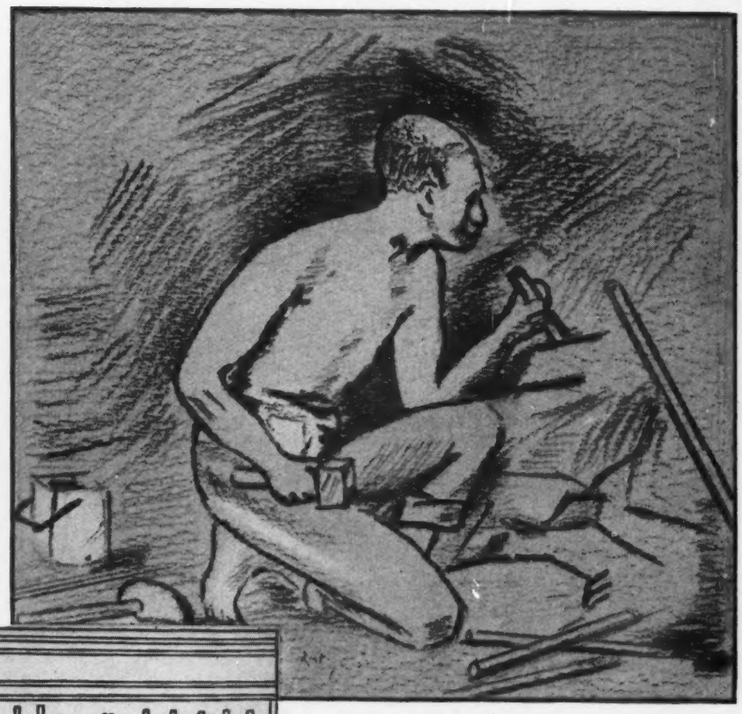
With no explosives and few metallic implements available, the excavating of rock in the early days was a tedious and laborious process. In driving tunnels, one of the favored methods was to heat the rock face with fire and then to dash cold water against it, the sudden contraction causing the rock to fracture and spall. Blocks of stone were removed in various ways. Wooden wedges were driven into holes drilled with tubular drills and wetted, thus causing them to swell and break the rock asunder. Sometimes the holes were drilled close together in rows and the rock between adjacent ones was broken out to form a groove. Again, saws were used. The drills or saws

Manufacture of Rock Drills

C. H. Vivian

EGYPTIAN DRILLERS

These workmen of ancient days are turning a drill by alternately pulling a strap wound around it. Each has a foot against the base of the drill to hold it in place, while the overseer sits on top of it to weight it down. The foreman at the left is touching the foot of one of the drillers with a prong to keep him at work.



THE HAND DRILLER

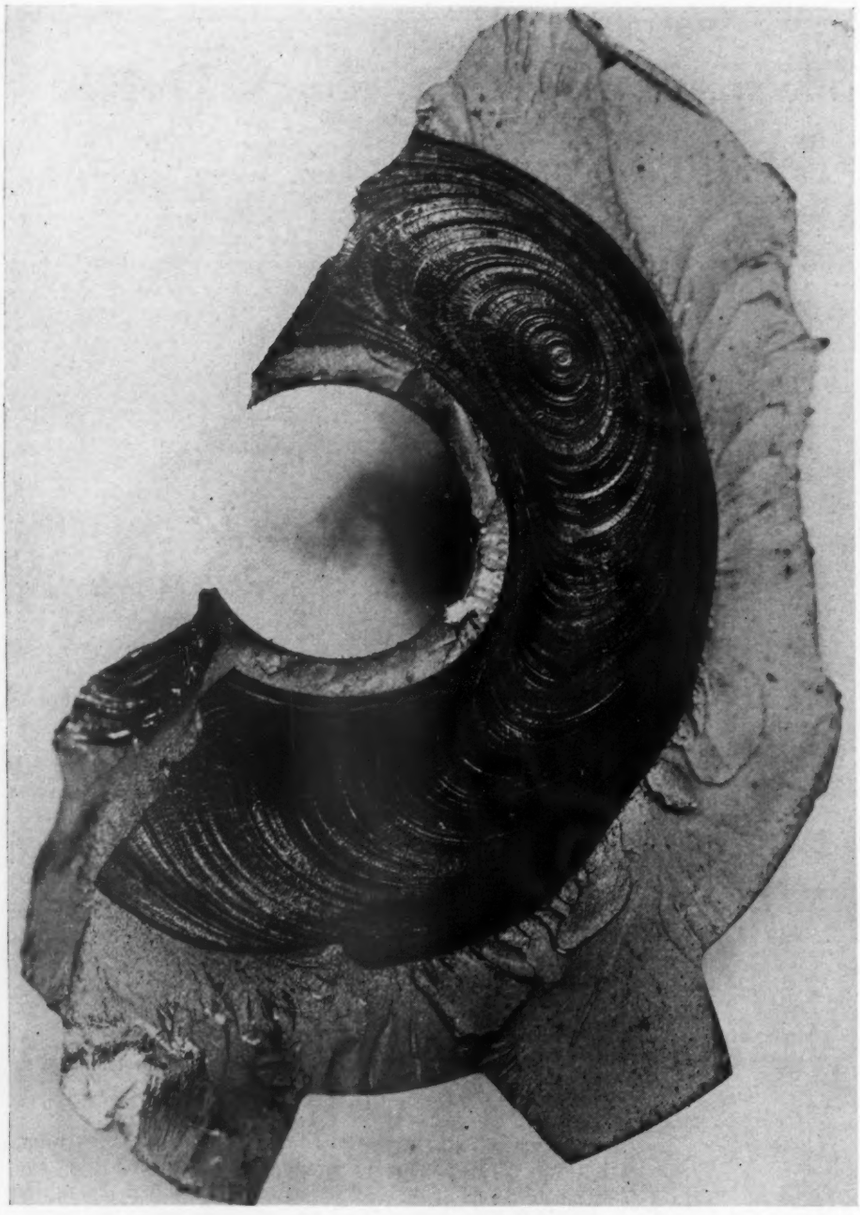
Reproduction of a cover design of the Colombian publication "Mineria" showing a miner at work underground.

were supplied with powdered corundum, or some other hard, gritty material, which, together with water, served as an abrasive. Regardless of what tools were employed, the power to operate them came entirely from human muscles.

The great aqueducts of Rome and elsewhere, and other momentous projects, all entailed extensive excavating operations. In 52 A.D., the Roman Emperor Claudius had a tunnel driven under Monte Salviano for a distance of 3½ miles to drain Lake Fucino in the Italian Province of Aquilo. Forty shafts and numerous inclined galleries were sunk to depths as great as 400 feet, and through these the broken material was hoisted to the surface in copper buckets having a capacity of a little more than one cubic foot. It required eleven years and the work of 30,000 men to complete the 6x11-foot bore. One hundred men could do it today in a few months and with practically no back-breaking labor.

Gunpowder was introduced around the fourteenth century, giving man for the first time a means of shattering rock. In order to provide the powder with an effective foothold so that it could exert its disruptive force, the rock had to be penetrated with holes, and it was this need that gave birth to the art of rock drilling. Two principal hand methods were developed: churn drilling and hammering. The former system, which is applicable to down-hole work only, consists of alternately raising and dropping a bar of steel having a chisel bit at its cutting end. It is still used in India and in some other parts of the world where labor is inexpensive. Hand hammering is so well understood that it requires no description here. It was universally practiced in underground mining operations for several centuries. For putting in holes of not more than 3 feet in depth, single-hand drilling sufficed, with one man both striking and holding the steel. For heavier work, one or two men wielded 2-handed hammers and another held and turned the steel.

Until about 65 years ago, all rock drilling was done by one of these manual methods. The invention of dynamite by Alfred Nobel in 1863, and the development of the first practical mechanical rock drill by Simon Ingersoll and Henry C. Sergeant in 1871, revolutionized the procedure of excavating



A PISTON FRACTURE

An enlarged photograph of a piece of steel broken from the striking end of a rock-drill piston while in service. The fracture was induced by an inclusion at the center of the concentric rings at the upper right. The size of this trouble maker may be judged from the fact that the central opening in the piston is ¼ inch in diameter. Under the very heavy impacts to which a piston is repeatedly subjected, even such minute imperfections in the steel will lead to failure. Note how the break has gradually spread out in conchoidal formation. This is typical of the impact fractures that result from such causes.

rock. Together, they have had a far-reaching effect upon our civilization. From the basic design of Ingersoll and Sergeant there has evolved, through numerous improvements and refinements, the modern, high-powered rock drill that is manufactured in various types and sizes to meet every drilling requirement. The names of those responsible for these betterments would make a long list; but foremost among them was J. George Leyner, originator of the hammer-type drill and the first to use hollow drill steel.

Throughout this development, the designer has collaborated with the metallurgist, for with each improvement in drill performance the moving parts have been subjected to more severe service and have demanded more resistant materials of construction. In addition to this requirement, the aim has been to make drills more powerful without increasing their weight.

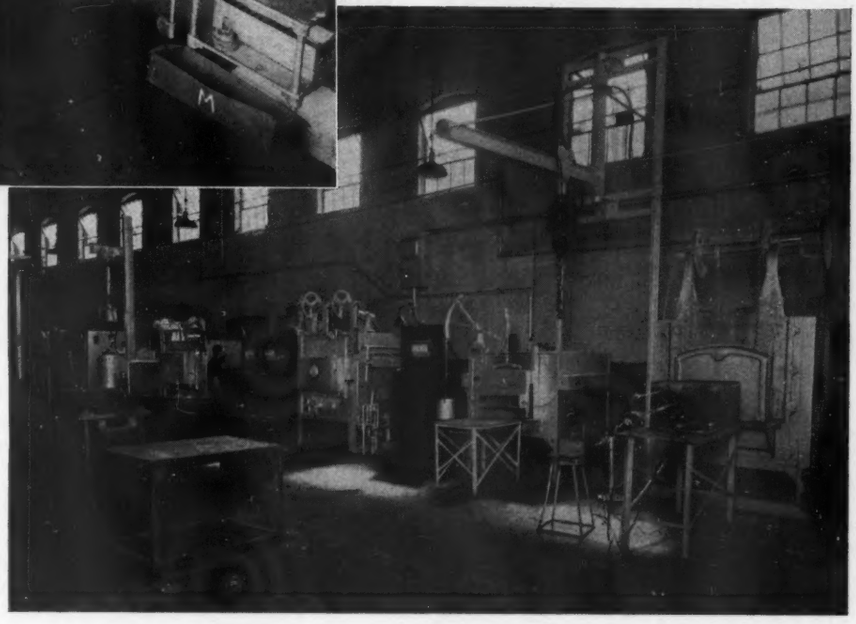
The extent to which the operating efficiency of the rock drill has been increased, and, conversely, the cost of drilling rock has been reduced, is not generally realized. One reason for this is that drills are sold on a different basis than are some other types of mechanical equipment. A pump, for example, is given a rating of so many gallons per minute, while the capacity of a compressor is specified in cubic feet per minute. In either case, it is possible to make a direct comparison between models of 25 years ago and those of today in terms of output. Rock drills, on the contrary, have always been sold more or less on a weight and size basis, the various classes such as Jackhamers, drifters, and Stopehamers being designated as light, medium, or heavy. If they were offered on the same basis as pumps or compressors, they would be rated according to their capacity to do work—according to the number of inches of hole they could drill per minute. Actually, it is not feasible to do this, as there are too many variable factors to be taken into consideration, such as the kind of rock, the air pressure, the size of the drill bit, and the skill or experience of the drill runner. This is unfortunate for the rock drill, for if such a rating could be adopted it would at once be apparent that the strides that have been made in improving its performance compare favorably with those made in the case of other types of machines.

Regardless of this situation, however, the fact remains that every mining, quarrying, or contracting company ought to purchase a rock drill with the thought in mind that it is designed for putting in drill holes and should judge the merits of the tool by its capacity to do a given amount of work in a given period of time. If it were possible to buy a box of 50 blast holes, just as it is possible to buy a box of 50 sticks of dynamite, it would be found that the cost of those holes has been more than halved in the course of the past 25 years; and the cost will continue to go down with the continual betterment in rock-drill construction and design.

In support of the foregoing statements, it might be well to give here the results of performance tests which Ingersoll-Rand Company made recently with all the drifter drills of medium-weight that it has offered to the trade since its first hammer-type drill was introduced in 1913. These tests were conducted under identical conditions —the rock, drill bits, air pressure, and drill operators being the same in each case. As the results were tabulated in terms of percentages, they can be accepted as representative of those that are to be obtained in any kind of rock.

One of the tests was for the purpose of determining the drilling speed per minute. It showed that the current DA-35 drifter will penetrate rock (in this instance Barre granite) nearly four times as fast as the No. 18 which appeared in 1913. In other words, to state the comparison in terms of capacity to do work, the purchaser of a DA-35 will get nearly four times as many drill holes per shift as he did 25 years ago.

A second test had to do with air consumption. It disclosed that the DA-35



HEAT-TREATING FACILITIES

Proper heat treating of rock-drill parts is a vitally important phase of their manufacture. The entire process is under the close supervision of the metallurgical department, and the most modern furnaces and other equipment are provided to insure consistently accurate treatment. At the left is a section of the pilot heat-treating plant in the metallurgical laboratory. Here all tests of raw materials are conducted and new heat-treating processes are thoroughly tried out. Below is a small section of the production heat-treating department. Each furnace is electrically fired and equipped for automatic temperature control. Four of them are of the controlled-atmosphere type.

uses only 45 per cent as much air per inch of hole drilled as did the No. 18. Expressed in another way, the volume of air that drilled 45 holes 25 years ago will now drill 100 holes.

From the data obtained in these and other tests was computed and charted for the 25-year period the investment required to drill one inch per minute. This revealed a reduction of 55 per cent, which means that every 45 cents invested today in a DA-35 drill will buy as much drill hole as $1 bought when the No. 18 was in use.

Illuminating as they are, these figures do not tell the entire story of rock-drill advance, for it is also a fact that along with the improvement in drilling performance, drills have become more reliable and longer-lived. In consequence, each drill will do more work in the aggregate, and will do so with lower up-keep and repair costs per drill shift. When evaluated on the basis just outlined, which is the only really equitable one, it will be seen that modern drills, regardless of their first cost, are by far the most economical that have ever been available.

In order to bring out more clearly the extent of the contribution made by the mechanical rock drill to that branch of work involving rock excavating, let us look at some comparative figures. Referring to the *Mining Engineers' Handbook*, by Robert Peele, we find that with two men striking the steel and one man holding it, the average progress that can be made in eight hours in various classes of rock is: hard limestone, 13.6 feet, or 4.4 feet per man; gneiss, 11.28 feet, or 3.76 feet per man; hard porphyry, 6.4 feet, or 2.13 feet per man; and hard granite, 11.2 feet, or 3.73 feet per man. In Canada, with two men drilling, from 6 to 8 feet a shift in granite is considered good progress in mine prospect work.

A modern mechanical rock drill requires only one man for its operation and will put in from ten to fifteen times as much drill hole as has just been cited, or what is equivalent to the labors of from 30 to 45 men. A direct comparison is offered by Rhodesian mines, where both hand and machine methods are in use. A Kaffir "boy" with a single-hand hammer can pound a 2½-foot hole in quartz in a shift. The same workman will drill 30 holes, each 4 to 5 feet deep, with a Jackhamer.

The practical benefits of this marked increase in drilling efficiency, though obviously great, are perhaps not fully appreciated even by those identified with operations entailing the excavation of rock. Actually, they are at least partly responsible for the average man living on a scale that at one time only a comparative few could afford. This is true because drilling enters into the production of many of the materials required for the houses in which we live and for those countless articles that we use every day.

Steel, copper, lead, zinc, and other base metals would sell at far higher levels than they do if the ores from which they are derived had to be drilled by tedious and costly hand methods. And as these metals are utilized in thousands of ways to produce everything that mankind wears, consumes, or uses, it follows that we would either be doing without many of the things we now consider commonplace or be paying a great deal more for them if it were not for the rock drill. Gold and silver mining would necessarily be confined to the exploitation of rich deposits, for it would not be economical to recover low-grade ores. Virtually no developmental work would be possible; and mines would be shallow pockets similar to those that are found wherever primitive methods alone are employed.

The great dams and hydro-electric projects with their varied benefits such as flood control, navigation, irrigation, and inexpensive power might, conceivably, never have been built if the drilling they involved had had to be done manually. Consider, for example, what it would have cost and how long it would have taken to construct Boulder Dam without the aid of mechanical rock drills. Before the concrete barrier could be poured it was necessary to drive four great tunnels through which to divert the Colorado River. These bores were 56 feet in diameter and had an aggregate length of 15,909 feet. To advance the huge working face with its area of 2,463 square feet, an average of 174 drill holes was re-

THE INSIDE STORY OF STEEL

At the left is an etched piece of carbon tool steel magnified 3,000 times. This steel was heated to too high a temperature before quenching, resulting in the condition which caused it to fail in service. The circles indicate coarse martensite which, in itself, induces brittleness. The arrows point to retained austenite which greatly increases brittleness. Only by the use of a precision research microscope at very high magnification can retained austenite in such minute quantities be detected. Today, visual and photographic microscopy are among the metallurgist's most effective tools. In the course of regular manufacturing procedure, Ingersoll-Rand actually polishes, etches, and examines under a microscope many vital rock-drill parts before shipping them. At the right is the metallographic microscope with which the picture was made. The operator is examining a specimen visually. This is the latest development in equipment of this sort. Specimens may be examined in a bright light, dark field, or under polarized light. The mounting contains shock absorbers to dampen vibrations, and staff members often work at night to escape the effect of building disturbances.

quired, this figure representing the total number of holes in the rounds in the several areas into which the cross section was divided to facilitate progress. Ignoring the extra footage in the case of some holes driven at an angle, as well as that attributable to the fact that the advance made with each blast did not normally equal the depth of penetration of all the drill holes, the drilling required was equivalent to one hole 525 miles long! Using truck-mounted drill carriages, which made it possible to concentrate as many as 25 drills for a joint attack, the contractors drove the tunnels in approximately one year.

It is impossible to do more than guess at the length of time the job would have taken had hand drilling been employed, for it is inconceivable that places could have been provided at the face to permit 25 groups of hammermen, or 75 men in all, to work there simultaneously. Assuming, however, that this number could somehow have been accommodated, we can draw an interesting comparison. The 25-drill carriage was used to drill the bench section of the bores which was 30 feet high and extended across the full width of the tunnel—56 feet. In an average round, the N-75 drifter drills put in 96 holes each 16 feet deep in four hours. The total footage was 1,536 feet, or an average of 15 feet per drill per hour. On the basis of the figures for hand drilling, as previously given, it would have taken 40 hours, or ten times as long, to put in a round. As the tunnels were started in 1931, they would still be underway and would not be finished for three more years. Furthermore, as the driving of the tunnels constituted only about one-fourth of the total rock excavation incidental to the construction of the dam, it is evident that completion of the entire undertaking would still be from 20 to 40 years distant.

Reference was made earlier to the important part metallurgy plays in making possible the modern high-powered rock drill. As a matter of fact, there is a continual struggle going on between the designing and manufacturing staffs of every rock-drill manufacturer of repute; and the metallurgist, whether he likes it or not, has to act the role of mediator. The designing staff's primary objective is to develop drills that will outdo existing ones. This means, in substance, modifying the design so as to obtain a harder blow, for it is only by driving the piston against the drill steel with greater force that greater penetration of rock is obtainable. When such an improved design comes from the drafting boards, the manufacturing staff, figuratively speaking, shrugs its shoulders and says: "We can make it, but will it stand up?"

Right there and then the problem is placed gently but firmly in the lap of the metallurgical department. It is its job to find materials that will stand the gaff. To understand the seriousness of this continually recurring assignment, we have only to recall that a rock drill is virtually an engine of self-destruction. During every minute of its operation there are approximately 2,000 violent collisions between the piston and the shank of the drill steel. Both members are composed of tool steel; yet, with steel striking steel with a cumulative impact of something like 40,000 foot-pounds every 60 seconds, the piston is expected to stand up day after day. The drill steel is, of course, changed every few minutes, and damaged shanks can be easily and inexpensively repaired. The piston, however, must remain in the drill, repeating its tremendous hammering action hour upon hour.

We have singled out the piston for major attention because it, by all odds, has to endure the greatest punishment. But the other parts of the drill must likewise with-

stand severe service conditions of one kind or another. Drills are subject to incessant vibration, they are handled roughly, they often lie in grit-laden water. Both air and water are fed through them and thence into the hollow drill steel, and these fluids are apt to carry with them abrasive or corrosive matter. As the demand always is for a drill of greater power but not of greater weight, the metal sections cannot be increased in this respect. Hence the only way to make these parts stronger is to put better material into them.

To satisfy these requirements, an unremitting search for steels of higher quality and greater uniformity is conducted by the rock-drill metallurgist. The quest has been going on for years, and it will continue so long as rock drills are made. It is within the bounds of truth to state that the necessity of obtaining better steels, forced upon rock-drill makers, has had the effect of improving the products of numerous steel manufacturers. As a consequence, higher-grade materials have become available to steel users in general.

Many kinds of steel are needed to build a rock drill. Numerous parts call for alloy steels, and these, in turn, must be of several varieties. The service demands upon some parts are relatively light, and any reputable steel mill easily produces the material for them. Such instances are comparatively few, however, as most parts require the best metal that can be had, plus all the additional improvements that the metallurgists of the drill company and the steel mill combined can bring about.

As might be expected, the piston calls for the greatest amount of attention in this regard. Since the advent of the Ingersoll-Rand Company's line of hammer-type drills more than 25 years ago, its metallurgists have been combing the world for a superlative piston steel. Their investigations have led them into every steel-producing center in Europe and America, and the foremost technologists of the ferrous universe have knitted their brows in an effort to comply with the request for a product much superior to the best of their previous efforts.

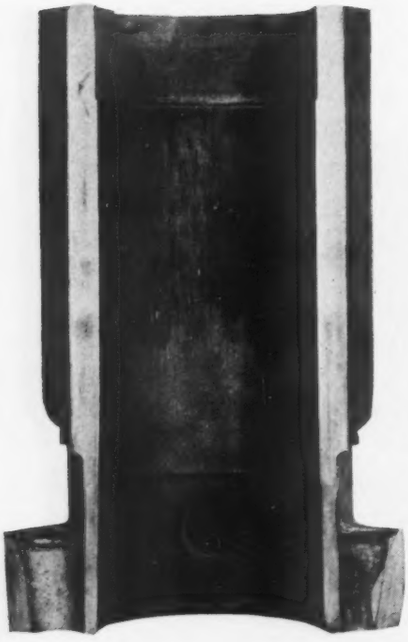
The need for a superfine piston steel was occasioned by the change in rock-drill action necessitated by the hammer design. In the old piston-type drills, in which the piston and drill steel were integral, the piston assembly weighed as much as 125 pounds and shuttled back and forth in the cylinder only about 325 times a minute. The total travel each minute, including 650 reversals in direction, was around 300 feet. This resulted in a velocity at the instant of impact that was high for the materials of that time to withstand; but it should be remembered that it was the bit at the end of the drill steel that had to resist the shock, not the piston. Furthermore, the bit was striking rock and not steel.

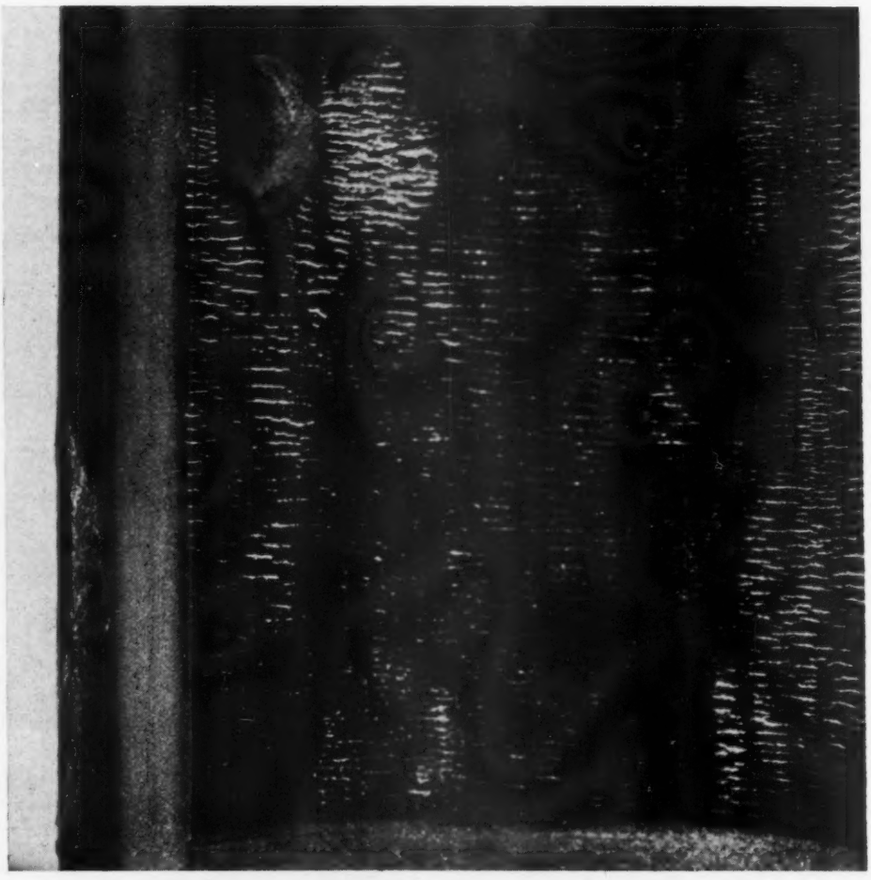
With the shift to the hammer type of drill, the action was materially changed. The drill steel remains stationary: only the piston moves. Moreover, as also has been pointed out previously, the piston strikes against steel. The piston has been reduced to only a fraction of its former weight, the working stroke shortened, and the velocity increased. By way of example, take the piston of the new DA-35 drifter. It weighs only 9 pounds 5 ounces and strikes 1,800 blows a minute when operated with air at 80 pounds pressure. As it has a stroke of 3⅜ inches, the total travel of the piston in a minute is 1,012 feet and 6 inches. Included in this travel are 3,600 reversals in direction at each of which the 9-pound projectile comes to a complete stop. Just what the mean velocity and the velocity at the instant of striking the drill steel may be, cannot be accurately determined, but the foregoing figures are ample evidence that they are very high. Small wonder that the metallurgists have hunted far and wide for a piston steel of preëminent quality!

Pistons are fashioned from the highest grade of tool steel obtainable. This steel is manufactured to rigid specifications pre-

REVELATION OF THE MAGNAFLUX

These pictures, from left to right, tell a story of rock-drill abuse in the field. The circle on the stoper cylinder (one) indicates a dent that was evidently caused by a blow of some sort. Upon being magnafluxed, the area was found to be cracked (two). The third illustration shows the crack on the inside of the cylinder, and the fourth, which is a microsection through the wall of the cylinder where the crack occurred, reveals that it does not extend entirely through it.





SCORED CYLINDER

No one would expect to run a gasoline engine without lubrication, yet the compressed-air engine, the rock drill, is frequently neglected in this respect. Its piston, having no compression rings, must fit the cylinder with practically zero clearance. Without adequate lubrication this piston, delivering powerful hammer blows at high speed, is bound to injure the cylinder by scoring. These photographs illustrate conditions resulting from operation without sufficient oil. At the right is an enlargement of part of the surface of a scored cylinder (left) treated by magnaflux to expose and emphasize the damage.

pared by Ingersoll-Rand Company, and so far only a few mills have been able consistently to produce material of an acceptable quality. Each heat is subjected to a series of tests before it is rolled into the bar stock from which the pistons are formed. These tests include every recognized one at the command of the metallurgist. It is not enough that the chemical composition be right: the various elements must also be properly distributed throughout the structure to give it uniformity. Grain structure, smoothness of surface, hardness, freedom from inclusions, and hardening characteristics, among other qualifications, must likewise be closely scrutinized. From the time a melt of 10,000 pounds of steel is poured until it is manufactured into pistons, it undergoes approximately 1,000 individual tests.

Virtually all the larger parts of a rock drill save the piston are made of alloy steel the nature of which varies with the service requirements. As in the case of the piston material, these metals are subjected to routine tests, some of a very exhaustive character and others less so but nevertheless thorough. Nearly all the steels can be termed special in that they are produced according to definite specifications prepared by the drill maker. The steel from which cylinders are forged is known as a double-converted, special cylinder stock. The interior surfaces of cylinders are given a mirrorlike finish, and the metal must be absolutely free from blemishes, both inside and out. To insure this, all defects are chipped out of the steel when it reaches the bloom stage so as to safeguard the subsequent billets from weak spots which might later be the cause of failure of finished parts.

Only slightly less exacting than those for piston steel are the requirements laid down for the chuck bushing in which the drill steel shank is held and by which the steel is rotated. This part is of relatively thin section, yet it is subjected to great friction. To withstand this and other service demands, it must be made from material of exceptional quality capable of being hardened so that it will scratch glass and be free from all impurities.

After the metallurgist has found acceptable materials for the vital drill parts, and has seen to it that each lot is up to the standard set, his work has only begun. For even the finest steel must be processed with the utmost care during its progress through the plant if the finished parts are to perform satisfactorily when they are assembled and the drill is subjected to 1,800 or more violent shocks and vibrations per minute. Without going into details regarding the manufacturing procedure, we can hint at what it entails by stating that approximately 45 separate operations are required to form a piston and more than 100 to complete a cylinder.

Virtually all the steel parts used in Ingersoll-Rand drills are forgings made by a battery of air-operated drop hammers that constitutes the second largest installation of the kind in an American industrial plant. Forging is more expensive than casting; but hammering gives the steel not only a finer texture but also added strength. It is of the utmost importance that the forging temperature be closely regulated, and the metallurgist therefore checks it continually. The machining operations are conducted in a shop that contains the most modern equipment available and by expert workmen many of whom have been in the employ of the concern in question for a quarter-century and more.

Anyone familiar with machine-shop practice need not be told that the equipment—including jigs and fixtures—necessary to perform the multiplicity of operations required to make the manifold parts for the different types and sizes of drills produced by the company represents a tidy fortune. It goes without saying that meticulous care has to be exercised at every stage of manufacture. In fact, though it may be difficult for the layman to believe, a rock drill, despite the battering service which is its lot, is built with a watchmaker's

precision. In support of this statement, we can say that the piston must be machined within 0.0005 inch of its specified diameter, and that the allowable tolerances of some of the other parts closely approach this fine limit. A better grasp of what this means can be had when it is realized that 0.001 inch is less than one-third the thickness of a sheet of newspaper. Throughout the machining process, every part is periodically inspected and measured.

Once the parts are made, they must be heat treated to give them the exact degree of hardness that best fits them for their respective services. Naturally, the treatment varies with the part; and, to meet the several requirements, many different types of furnaces are used. In every case, they are fully provided with temperature regulators and recording instruments that insure precise treatment.

As has already been pointed out, the tools with which the metallurgist works are many and varied. Where there are two or more recognized methods of obtaining the same information, all are used, for each additional check insures greater accuracy. In the matter of hardness determination, recourse is had to half a dozen procedures, each especially adapted to the needs of certain tests. The oldest instrument for ascertaining hardness is the file, and despite the development of intricate machines it is still in good repute. The scleroscope was the first hardness-testing device, and it was followed, in turn, by the monotron and the Brinell and Rockwell machines. The latest is the Vickers, which is designed to test very hard metal in thin sections.

Twenty-five years ago a chemical analysis was considered sufficient check on the composition of steel for rock-drill manufacture. Today it is augmented by the microscope, a tool that has become indispensable to the metallurgist. To the eye of the trained technologist, the microscope reveals the internal structure, grain size, and crystal arrangement of the metal, factors that have important bearings on the suitability of a steel for a specific use and which determine how it will react to heat treatment. Modern equipment includes a machine that serves the dual purpose of examining sections visually and of taking 8x10-inch photomicrographs of them. Magnification up to 3,500 diameters is routine work in the Ingersoll-Rand laboratories. These microscopic investigations are the means by which both raw materials and semifinished and finished parts are controlled. They are particularly valuable in connection with heat-treating practices, in that they make it possible to ascertain quickly whether or not they are adequate.

This story of the unremitting vigilance that is exercised in the manufacture of modern rock drills that can meet the severe requirements of the service for which they are designed could be carried on indefinitely. In addition to steel, a rock drill contains several parts of bronze and one or more of rubber. These materials undergo the same rigorous tests to which the steel is subjected, and every precaution is taken to obtain the highest qualities available.

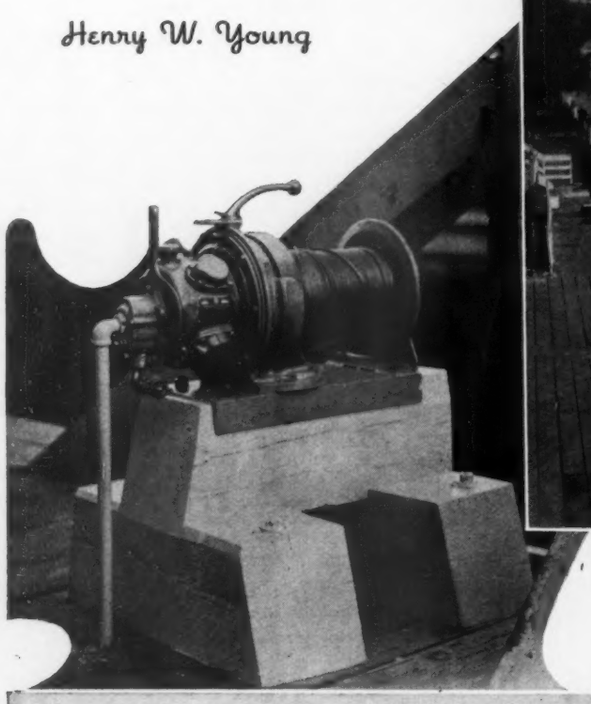
To sum up, we can only repeat the metallurgist's maxim that, so far as materials for rock drills are concerned, "the best is none too good." The art of building drilling equipment is an exceedingly restless one. Designers, metallurgists, and manufacturing specialists are ever on the alert for ways and means that will help them to turn out a superior product. No tool of equal size has undergone such extensive changes since it was introduced; and none receives as much punishment in service. The foregoing account, while far from complete, will perhaps bring the reader to a realization that the excellence of any rock drill must inevitably be gauged largely by the practical experience, engineering ingenuity, research facilities, manufacturing resources, and general reputation of the company that makes it.

DRILL-PRODUCTION TEST

Every rock drill made by Ingersoll-Rand Company must pass a rigid test under actual drilling conditions before it is approved for shipment from the factory. To insure the uniformity of these tests, blocks of granite weighing from 30 to 40 tons each are regularly obtained from quarries at Barre, Vt. The standard-production test room shown here is provided with every facility for testing all types of rock drills and paving breakers. One of the many tests to which the paving breaker is subjected is that of measuring the rate at which it will drive a steel into pure lead. Some of the pots used in this penetration test are seen in the center of this picture. At the extreme right is a pit for testing stoping drills. At the left are shown drifters and Jackhamers undergoing tests.

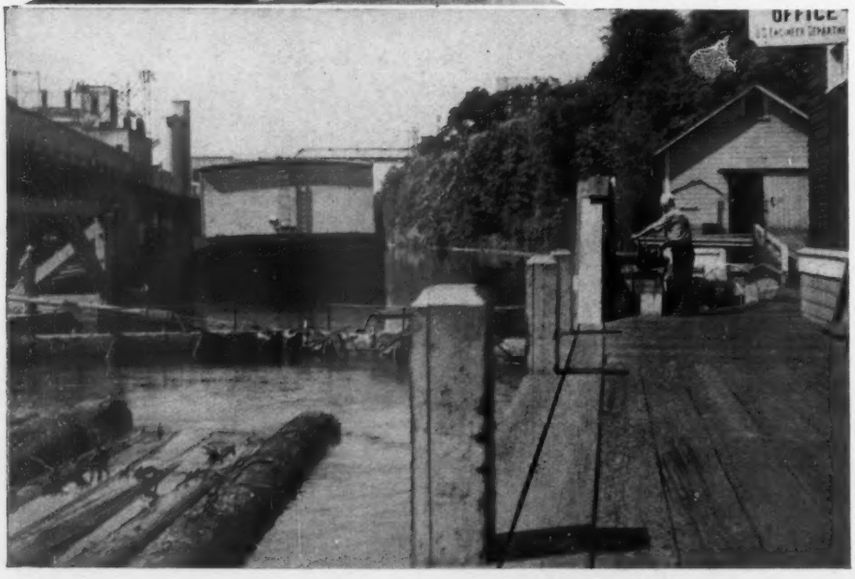
Utility Hoist Does a "Mule's" Job

Henry W. Young



HOISTS REPLACE TUGS

Small tugboats pushing log rafts through the locks (above). With this procedure, the tugs had to go back through idle. Now the air-operated hoist at the right in the view below tows the logs up to the gate and then opens the half on its side of the lock. Left is a close-up of one of the hoists.



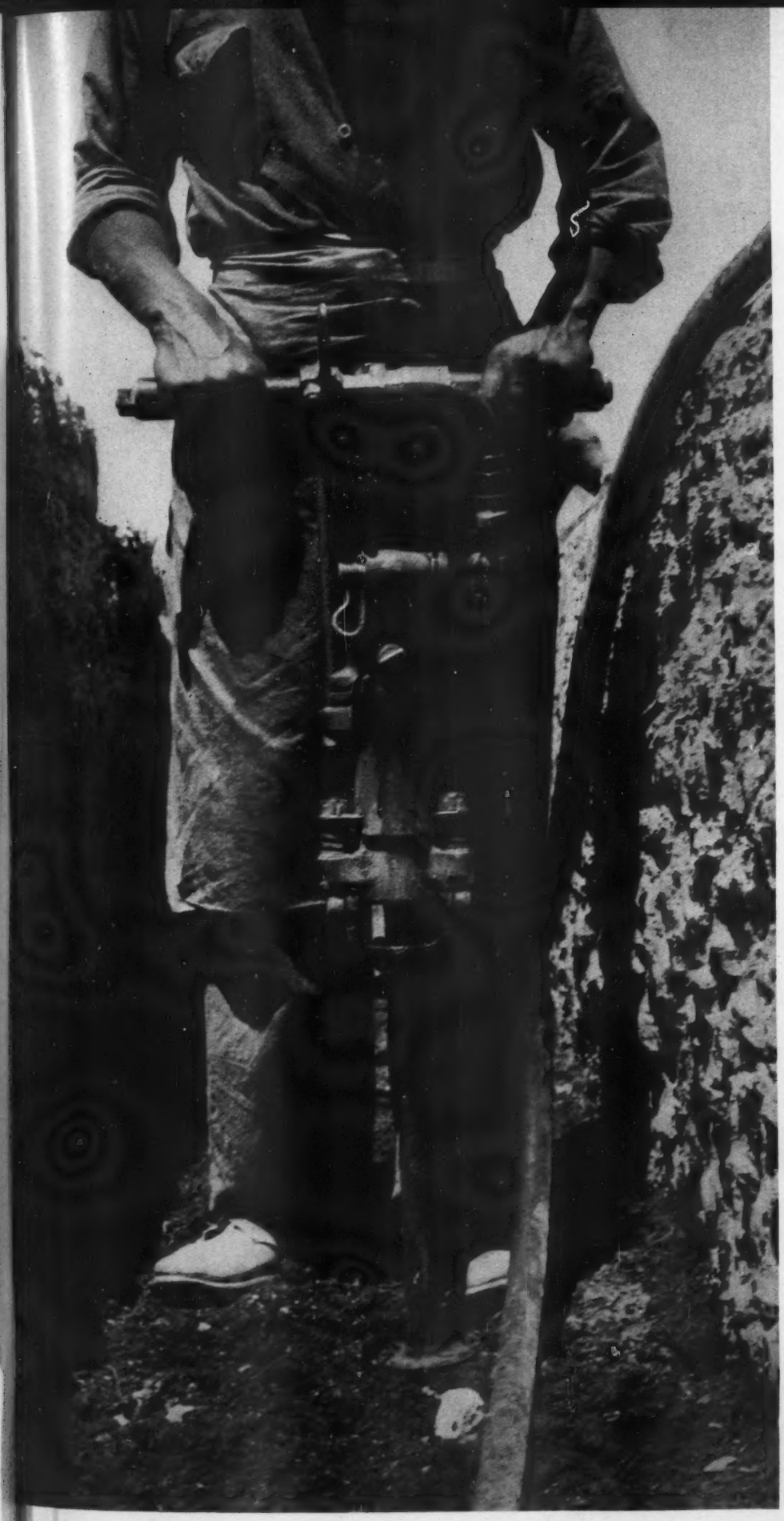
SIXTY years ago, five locks were built around the falls in the Willamette River at Oregon City and West Linn, Oreg. No great amount of shipping has made use of them; but a vast number of logs has passed through the locks annually ever since. Two large paper mills of the Crown-Willamette Paper Company and The Hawley Pulp & Paper Company, at West Linn, together consume some 70,000,000 board feet of timber a year. Besides, there are sawmills above and below, and their ripping bands are fed to a large extent with logs that are transported by water from the forests of the Columbia and the Willamette basins.

During all these years the locks have been manually operated, the wickets and gates being opened and closed by hand winches. Then, a few months ago, the U. S. Engineers decided to provide small compressed-air hoists to act as "mules" in towing the log rafts through the locks, a service that had heretofore been performed by two small tugs. The trouble with the existing system was that the tugs had to be passed down through the locks idle, which consumed time. With the hoists, on the other hand, all the tugs need to do now is to round up the small rafts and to push them into the first lock.

The pictures tell most of the story. Three hoists were installed at the three locks constituting the main lift, which totals 45 feet. They are of the Ingersoll-Rand Utility type, Size D6UL. A ¼-inch steel cable is used for towing, being attached to the dog line on each raft. At present, only one side of the canal has hoists. When a raft has been towed up to the gate, the line is cast off and a hoist makes itself useful by opening the half of the gate on its side of the locks, the line in that case being wound around a capstan rather than passed through a block. Obviously, with similar hoists on the opposite side, both halves of the leaf gates could be opened and manual operation eliminated altogether.

In putting in this installation, the U. S. Engineers did not include a compressor plant. Almost directly across the river was the mill of the Crown-Willamette Company; and by piping air from it for distances of approximately 200 to 600 feet all three hoists could be served, a small pressure tank with drain being provided for each hoist.

When it came to figuring out what the bill for the compressed air should be, several slide rules were burned out trying to compute the volume required, and in the end it was decided that the amount was so small, comparatively, that it would be just as well to set a low flat rate per year and let it go at that, an arrangement that is satisfactory to both parties.



JACKHAMER ROCK DRILL BEING USED TO CONSOLIDATE EARTH IN CUT-OFF TRENCH OF EL AZUCAR DAM, STATE OF TAMAULIPAS

Progress On Mexican Dams

THE illustrations on this page and on the two succeeding ones show some of the work that is being carried on by the Mexican Federal Government through the National Commission of Irrigation. The pictures refer to three important undertakings that will greatly benefit large areas in the states of Tamaulipas, Nuevo Leon, Michoacan, and San Luis Potosi. Following are some brief details concerning the dams that constitute the principal features of these irrigation works. In all cases the operations are well advanced.

El Azucar Dam, which was described in our April, 1938, issue, is being built in the State of Tamaulipas. Its purpose is to control the waters of the San Juan River. It is of the compacted earth-and-gravel type and will have a maximum height of 126 feet and a length on the crest of 3.6 miles. It will provide for a maximum storage capacity of 1,680,000 acre-feet of water. The spillway of this dam, so it is claimed, will be the largest in existence and will have a discharge capacity of 740,000 second-feet of water.

The construction of this dam is far advanced. During the first three months of 1938 more than 300,000 cubic yards of earth was placed in the earth-fill section. The building of the cut-off walls on both side hills is being actively pursued. The one on the northern side is well along, with 59,500 cubic yards of consolidated fill and 2,240 cubic yards of concrete in place. The diversion tunnel has already been holed through, and the inlet and outlet works have been lined with concrete.

The Cointzio Dam forms part of the Morelia and Querendaro Project on the Rio Grande at Morelia. It will create a reservoir with a storage capacity of 68,000 acre-feet of water. The dam is of the earth type, with rock fill on both sides. It will have a maximum height of 113 feet.

The Obregon Dam is being built in the Cardenas District at San Luis Potosi. It will impound the waters of the Alaquines River and will be of the earth-and-gravel type. It will be 89 feet in maximum height and have a crest length of 103 feet. Its construction involves the excavating of 80,000 cubic yards of material and the placing of 425,000 cubic yards of earth fill and 69,500 cubic yards of rock fill. As the pictures show, the most modern methods are being used in the construction of all these works.

The National Commission of Irrigation was created by the Mexican government in 1926. Since its organization it has entered upon an extensive building program which, upon its completion, will open up a vast acreage of land that now lies unproductive because of a lack of water. The foregoing dams are a part of this great project.

POWER SHOVEL WORKING IN THE QUARRY OF COINTZIO DAM, STATE OF MICHOACAN

CONSTRUCTING TRASH RACK AT ENTRANCE TO INTAKE TUNNEL AT COINTZIO DAM

REMOVING WOOD FORMS USED IN CONCRETING INTAKE TUNNEL AT COINTZIO DAM

CONSOLIDATING EARTH-FILL SECTION OF ALVARO OBREGON DAM, SAN LUIS POTOSI

Compressed Air Aids Candid Cameraman

ONE of the most vexing problems in connection with producing mechanically flawless enlargements from miniature camera negatives is that of removing all traces of water from the film following developing and washing. If even minute globules of moisture remain, they are likely to cause watermarks that cannot be obliterated, and these show up on the prints. The standard width of miniature camera film is 35 millimeters, or about 1.37 inch. In the case of an 8x10-inch print there is, accordingly, an enlargement of about 7.3 times, and on a picture of that size very tiny watermarks show up sufficiently to mar its appearance.

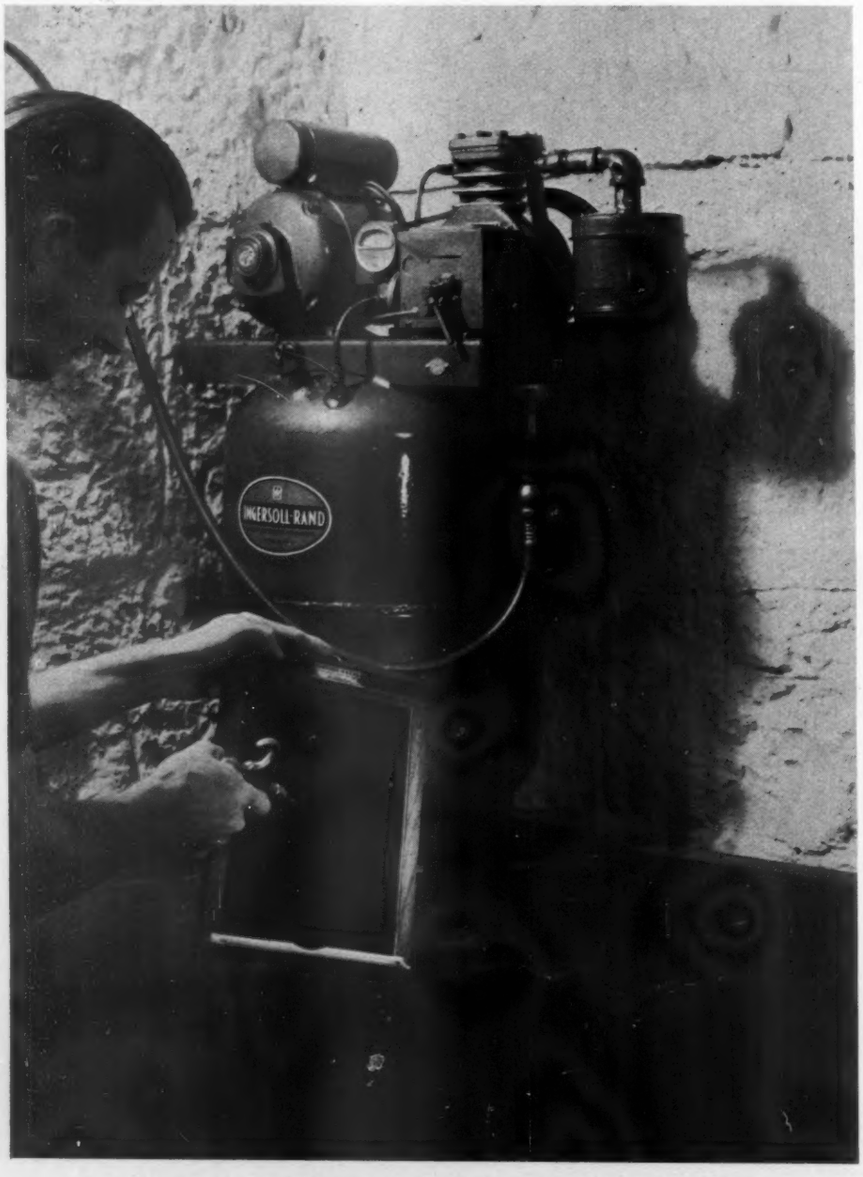
It is the usual practice to swab the wetted film with some absorbent medium such as cotton or chamois, or with a special preparation; but the results obtained are not all that the fastidious photographer desires. Such treatment is satisfactory for the base or uncoated side of the film; but it does not completely remove the water from the emulsion side.

Writing in *American Photography* for June, E. E. Bucher claims that he has surmounted the difficulty by blowing the rinse water off the film with a blast of compressed air. He uses air at 10 pounds pressure, and directs it at an angle in relation to the film surface, alternating as to the two sides. Successful operation requires that the discharge orifice be large enough so that no loud hissing noise be heard. It is also important that the air be free from dust and oil, which calls for a filter on the compressor intake and carefully controlled lubrication of the machine.

By this method, Mr. Bucher says, all surface water can be blown off in two minutes; but it is advisable to continue the air spray for two additional minutes. After that the film is allowed to dry in room temperature, around 70°F. Film thus treated reveals no watermarks when examined under a 7-power glass, and enlarged prints are all that can be desired.

In Mr. Bucher's laboratory, the air-blasting is done in the dark room. The compressor is set up outside, and the air led in through a hose. Other uses of the compressed air in the dark room are for drying the celluloid apron of the Correx tank, for removing dust from the enlarger and the camera, and, in particular, for blowing dust off the negative and its holder just before it is placed in the enlarger.

Prior to his successful experimental work with compressed air, Mr. Bucher rigged up a centrifugal device for throwing off the water. By mounting the film on a special frame and attaching it to the shaft of an electric motor, he revolved it at the rate of 1,750 rpm. But even this failed to obliterate all traces of the tiny water globules.



COMPRESSOR IN A PHOTOGRAPHIC SHOP

This Model A, air-cooled, electric-driven compressor is a recent acquisition of the photographic department of the Tennessee Valley Authority at Knoxville, Tenn., where many thousands of negatives are developed and printed each year. It is provided with an efficient filter on the intake, at the upper right. The illustration shows a plate holder being blown free of dust. The removal of fine particles of dirt from negatives is particularly important when enlargements are being made, as minute deposits then show up on the prints as larger blemishes.

High-Strength Plate Glass

AMONG the new applications of Tuf-flex plate glass is one that would seem to leave no doubt as to its exceptional properties. To test the performances of airplane radio apparatus at extremely high altitudes, a steel vacuum chamber was recently built by the Chicago Boiler Company for the United Airline Transport Corporation. To watch results, it was necessary to provide it with sight openings in which were set windows of Tuf-flex ½ inch thick.

Usually, U. S. Department of Commerce specifications require that instruments of this kind be exposed to conditions the same as those prevailing at heights up to 30,000 feet. When the test chamber was evacuated to a point where the pressure against its outer walls approached 15 pounds per square inch, the panes of glass held perfectly although deflected inward ⅛ inch. This made it possible to simulate conditions equivalent to those at an altitude of 67,000 feet, in other words, to determine how radio apparatus will work at more than double the elevation previously specified.

AQUEDUCT NEARS COMPLETION

THE completion of the Colorado River Aqueduct is now but a few months away—the expectations being that by this time next year water will be flowing across the mountains and desert to Los Angeles and twelve neighboring cities. On July 1 the program of construction, that has been underway since December, 1932, was 85 per cent finished. The midyear also marked the placing in operation of Parker Dam, from which Colorado River water will begin its long trip to the coast.

Notable engineering and construction history has been made on the aqueduct and its appurtenant works. The size of the undertaking is such as to stir the imagination, and yet it is being carried out according to schedule. There have been difficulties, to be sure, but the brains and resources to surmount them have always been available. Now that the end is in sight, it can be truthfully stated that no major construction job was ever prosecuted with greater diligence and fewer serious hitches.

The project is the largest on which a group of cities has ever coöperated; and it will undoubtedly lead to similar combined efforts where individual communities want or need some new or improved utility which no one or two of them alone can finance. The Metropolitan Water District, builder of the aqueduct, was organized under authority granted by the California Legislature in 1927. It is governed by a board of directors, with every member city represented and with none, regardless of its size, permitted to exercise more than 50 per cent of the governing power. The directors serve without pay. The cost of construction will be prorated among the thirteen cities according to their respective assessed valuations. They will share the benefits of the aqueduct water on a similar basis. As an insight into the character of the management that has prevailed and the caliber of the preliminary engineering studies, it is significant to note that the cost of the huge undertaking will be fully covered by the $220,000,000 made available by the original issue of bonds that was voted in 1931.

The project is composed of two principal parts: a main 242-mile aqueduct, and a 150-mile distributing system that is now being built to one-half its eventual capacity. The main aqueduct consists of 92 miles of 16-foot-diameter tunnels, 63 miles of concrete-lined canals, 55 miles of 16-foot concrete conduits, and 29 miles of inverted siphons. All the tunnels have been driven and lined except the 13-mile San Jacinto bore, of which about a mile remains to be excavated and 6 miles to be lined. In addition to Parker Dam, the chief auxiliary works include five pumping plants with a total lift of 1,617 feet, three reservoirs, and a 237-mile, high-voltage transmission line from Boulder Dam to the pumping plants.

More than 35,000 men have been directly employed on the various phases of the undertaking, all of them drawn from the cities that comprise the district. The number from each has been in proportion to its share of the cost. Indirect employment has been given to 25,000 persons in plants furnishing materials, supplies, and equipment used in the work. Up to July 1, more than 118,000 freight carloads of material had been utilized.

The additional 1,500 second-feet of water which the aqueduct will make available will be welcomed in Southern California, where the deficiency in moisture is acute. Having developed every accessible source of natural run-off water, the region has for many years drawn heavily on underground storage. It is computed that this water is being used up much faster than nature can restore it, the daily overdraft being estimated at 200,000,000 gallons. This has resulted in a gradual lowering of the water table and has created a condition where a prolonged drought might prove calamitous. Thanks to the engineering vision and financial courage of the cities that make up the Metropolitan Water District, supplemented by the power development at Boulder Dam, the water supply of Southern California has been amply safeguarded for many years to come.

A FIELD FOR YOUNG MEN

INFORMATION assembled by Prof. W. B. Plank, head of the Mining Engineering Department of Lafayette College, Easton, Pa., indicates that during the next few years, at least, the mineral industries will offer a promising field of endeavor for college-trained men. Despite the fact that last year's enrollment in the 53 mineral technology schools of the United States was the largest on record, it totaled only 7,200 students.

Fifteen or twenty years ago, mining and metallurgical engineers were in little demand. Many graduates of the leading schools could find no employment in their chosen fields and had to turn to other pursuits. Today the tables are turned, and the demand for trained men exceeds the supply. This condition is attributable not only to the considerably increased activity in the production of metals but also to the vast expansion in the development and application of alloys. Fortunately for the students, many of the American mining schools give a broad and liberal training that qualifies graduates for employment in any one of the large number of branches into which mineral technology is now divided.

The increase in the price of gold gave gold mining a new lease on life and created a need for hundreds of trained men. Activity has been particularly strong in South Africa, Canada, and the Philippine Islands. As nobody knows just how long the $35-an-ounce price of gold will prevail, the disposition of the companies engaged in mining the yellow metal is to boost their production and to make hay while the sun shines. As evidence of their eagerness to obtain competent technological assistance, it may be cited that virtually all the students in the 1938 graduating class of one of the prominent western mining engineering schools were offered positions in the Philippines at starting salaries considerably higher than those ordinarily offered. It hardly needs to be recorded that most of them accepted.

This and That

Homestake Plans New Deep Shaft

The Homestake Mining Company, America's leading gold producer, has announced that a new shaft, the tenth to be sunk, will be put down on its properties in South Dakota. It will be designed and equipped to operate from an ultimate depth of 5,000 feet. With its surface plant, it will cost approximately $2,500,000, and it is expected that 30 months will be required to complete it. The work will be done by regular Homestake forces.

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Unique Gas Holder

Near McKeesport, Pa., is a natural-gas field that has been used for the past eight years as a storage place for by-product coke-oven gas by the Carnegie Natural Gas Company. From its works at Clairton, Pa., a 20-inch pipe line transports the gas to the field, where it is now carried underground through the medium of seven wells in place of the 25 originally used. Care has to be taken to prevent blowing out old wells that may not have been properly plugged, and to this end the total pressure is generally kept below 65 pounds. Aside from the saving in cost as compared with gas-holder storage, the coke-oven gas, according to S. W. Meals, president of the company, enriches the natural gas, and the pressure of the incoming by-product gas opens up new pockets of natural gas which comes up with the coke-oven gas when the reservoir is tapped. Of course, for successful storage in natural-gas sands, the by-product gas has to be kept clean, for dust and tar would seal the sand pores, while sulphur would attack pipe lines and tubing. From 1930 to 1937, a total of 3,584,798,700 cubic feet of gas was pumped into the field and 3,942,324,300 cubic feet was withdrawn. The largest quantity stored at any one time in what is probably the world's most unique gas holder has been 600,000,000 cubic feet.

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Airplane to Aid Contractor

At an estimated cost of 5,000,000 francs, which is equivalent to $138,125 at the current rate of exchange, the aerial tramway on the Chamonix side of Mont Blanc is to be carried up the Col du Midi to an altitude of 11,890 feet, making it the highest of its kind in existence. Throughout its entire length of 3,917 feet, the extension will be in a glacial region where construction, under the most favorable weather conditions, can be pursued only four months in the year—from June to October. Men and materials required for the work are to be transported to the scene of operations by a temporary cableway that is to be hauled up to the mountaintop by a wire that is to be laid by an airplane.

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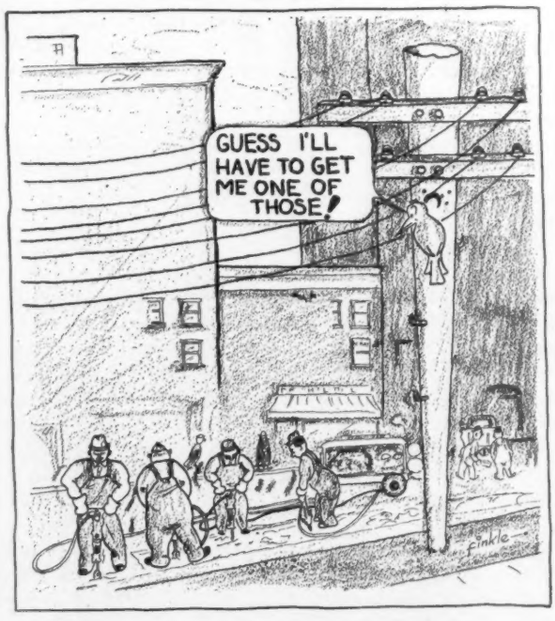
Then and Now

"Yes, mining has improved a great deal since I first went below in 1900," says an old shift boss in *Chemical Engineering and Mining Review.* There were no 'drys' then—we walked home in our wet clothes and dried them at home; there were no hard hats, gloves and goggles; no first-aid stations; no fancy gadgets for dust detection; no medical hospital. We had the heavy piston machines, but no light hammer drills, telescopic stopers, and automatic feeders; no detachable bits or hollow steel; no automatic drill sharpeners; and our drill steel did not last as long. We had no electricity underground —no lights, no locos, no trammers, no loaders. There was no 40-hour week and paid-for holidays; no company houses to live in at low rent; no swimming pools and cafeteria; no library; no club. Routine medical inspection was unknown—there was no compensation for miners' complaint and for minor accidents; no routine mine inspection; no end of shift firing-out; no water sprays to remove the dust. I believe these improvements have benefited both parties. The miner works less hours for much more pay and enjoys concessions and comforts hitherto unknown on mining fields. And the companies now obtain twice the tonnage per man employed, and can treat ore with less than half the metal content of that mined 30 years ago. Progress pays."



Fast Trains Need Stout Shoes

When streamlined trains were first put in service it was generally necessary after every long round trip to give them a new set of wheels throughout. Safety dictated this precautionary measure. It was found that the wheels that had up to that time been entirely satisfactory would not stand up when racing along at 90 and more miles an hour. This information comes from the engineering experiment station at Purdue University, Lafayette, Ind., which has in the meantime developed a new type of wheel to meet the needs of the high-speed service. In appearance, the new wheel is the same as that with which we are familiar: the difference is in the metal of which it is made. Heat-treated alloy steels are now used, with the result that "a streamliner can cross the continent 38 times on the same set of wheels."

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Kilogram is Standard of Weight

How many people are aware that the measure for all weights in the United States and in all other parts of the world is a standard kilogram consisting of a bar of metal composed of 90 per cent platinum and 10 per cent iridium—an alloy that is least likely to shrink or to expand, to lose or to gain weight. A bar of this description is in the keeping of the U. S. Bureau of Standards, Washington, D. C., and is one of 82 made more than 48 years ago by Johnson Mathey in London, England. There is in existence one master or "perpetual kilogram," and this is carefully stored away at the International Bureau of Weights and Measures in Sevres, France. Likewise at that bureau are four so-called "use-copies," and these serve for checking standard kilograms sent there for the purpose from all parts of the world. The perpetual kilogram is kept in an underground safe that can be opened only in the presence of the three members of the Bureau of Weights and Measures to whom are entrusted the three keys with which it is locked. The American standard kilogram was recently checked for the first time, and it was found to have gained eighteen-thousandths of a gram since 1889. "This change in the certified value," according to A. T. Pienkowsky, physicist at the U. S. Bureau of Standards, "is so small that considerations as to the possible cause are of very little value, the chief significance of the redetermination being that it shows a value practically identical with the former value, even for work of extremely high precision."

Industrial Notes

Solder in bar, pig, and wire form of high-tensile strength and low melting point is a new product of the National Cable & Metal Company. It is sold under the name of Hi-Tensile Solder.

India is planning to build a number of "submersible type of bridges" to save money, the contention being that many of those heretofore erected in that country are higher than circumstances demand.

The Blaw-Knox Company has recently been granted a United States patent on a new method of manufacturing tin plate. According to a statement made by that company, the amount of tin required by the process to produce an adherent and uniformly distributed coating is less than that needed by those in general use.

Salt, we are told, has some 1,500 uses, and one of the newest is that of seasoning lumber. Though still in the experimental stage, the process is being applied with favorable results by several southern mills working in coöperation with the U. S. Forest Products Laboratory.

Something new in anode holders has been placed on the market by the Owens-Illinois Glass Company. It is in the form of a bag which, together with the drawstring, is made of Fiberglas, an inorganic textile that is immune to the attack of all but hydrofluoric acid. The container can be easily cleaned for repeated use.

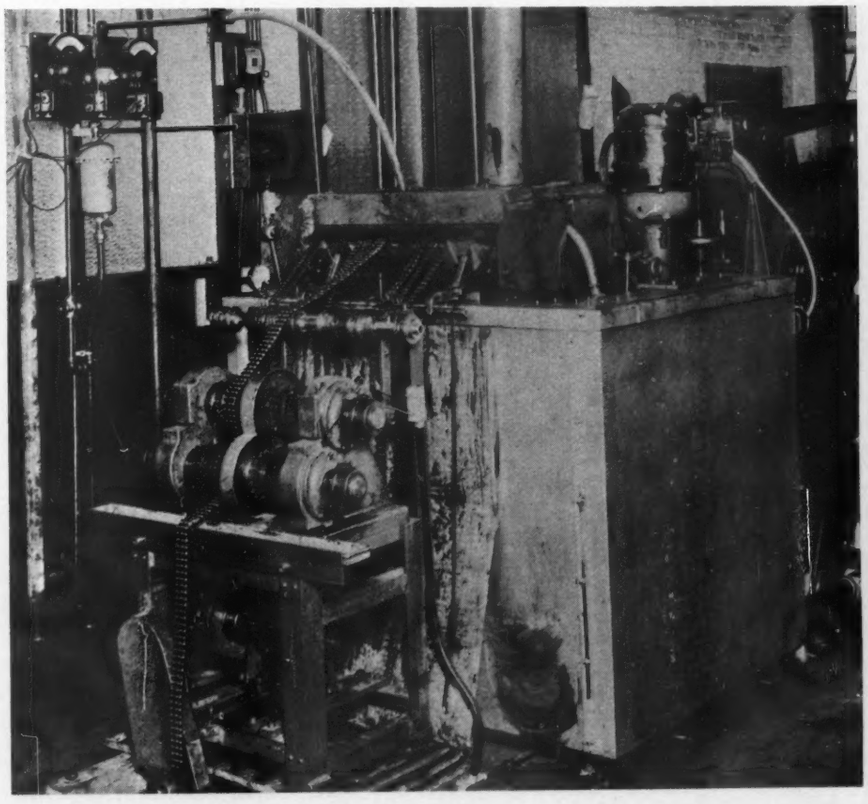
In fifteen months, tourists have paid the Federal Government the large sum of $81,000 for the privilege of inspecting the huge power houses at Boulder Dam. A percentage of this amount is used to pay the guides especially hired for this service, while the remainder is spent in maintaining the recreation areas around the dam and on the shores of Lake Mead created by backing up the waters of the Colorado.

Experts of the Imperial Airways (Great Britain) have developed a fumigating system, together with a suitable disinfectant, for ridding aircraft of insect pests. It is designed primarily for planes operating in tropical waters, so as to prevent the spread of the tiny creatures from one region to another. To determine how it would operate under service conditions, the system has been installed on the seaplane *Cassiopeia*, on a route in South Africa. The insecticide is forced under pressure through a network of piping which leads to each of the cabins, where it issues from vents in the form of a fine, dry spray that permeates every corner of the ship. The preparation used is noninflammable, has an agreeable odor, and is noninjurious to furnishings and clothing. At every stopping place along its run, the *Cassiopeia* is fumigated before the passengers embark. Health authorities consider this phase of aerial navigation an important one, and are awaiting the outcome of the tests with great interest.

A machine that detects the presence of tramp iron in nonmagnetic materials has been designed by the Illinois Testing Laboratory, Inc. In passing through it, the bulk material is surrounded by a radio circuit which can be set for various degrees of intensity. Any contained tramp iron will upset the balance of this circuit and cause both visible and audible signals to be operated through the medium of an amplifier. The machine can be used separately or in connection with a belt conveyor.

Expensive time-telling and recording instruments need no longer be discarded even if manufacturers have discontinued making the necessary replacement parts, for the General Time Service, a new company located at 1507 W. Vliet Street, Milwaukee, Wis., has announced that it will not only repair and recondition equipment of this kind both old and new but will also produce obsolete parts—wheels, pinions, gears, etc. It is fully equipped for that work; and its personnel includes craftsmen qualified to repair watches, stop watches, repeaters, program clocks, control clocks, time switches, chronometers, etc.

Rollers that can be varied in weight to meet the roadbuilder's differing needs are the latest development of the Hercules Company of Marion, Ohio. The rollers are of the 3-wheel type, and, except for the special water-ballasted front and rear rolls, are basically of the same design as those heretofore constructed. They come in several sizes. One model, for example, weighs approximately 7 tons with the rolls empty and a little more than 8 tons when they are filled. This can be increased to 16,800 pounds by loading two large tanks, which are mounted on opposite sides of the roller frame, with water.

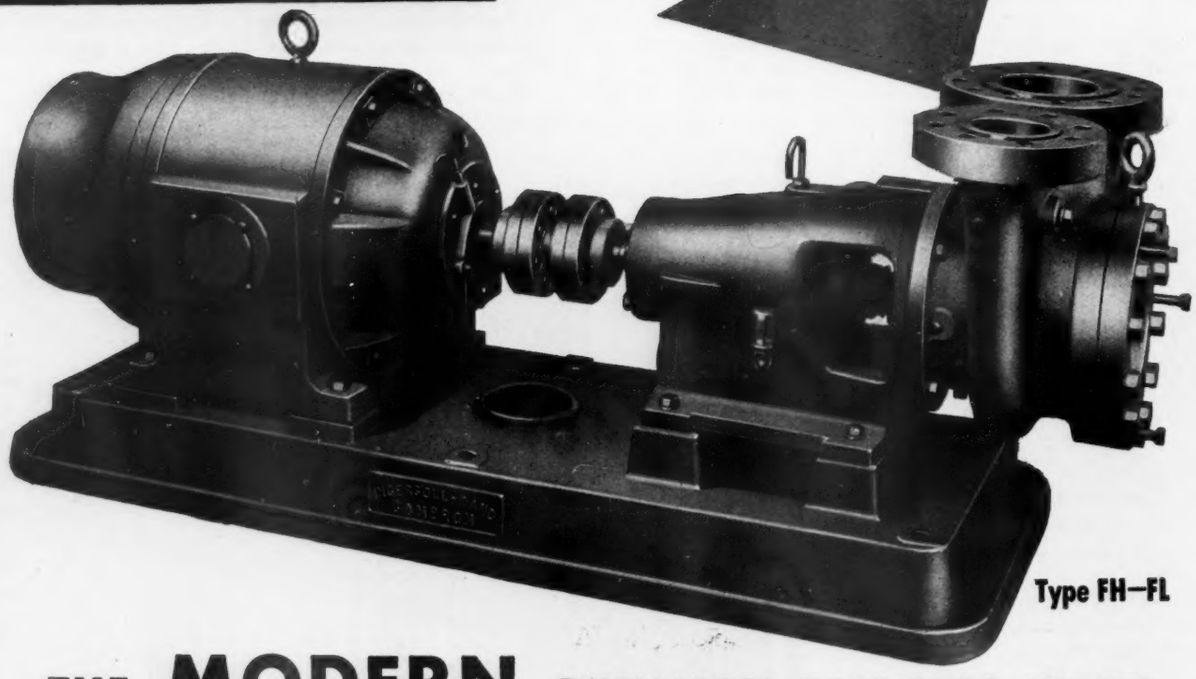


LUBRICATING ROLLER CHAINS

Before packing roller chains for shipment, the Diamond Chain & Manufacturing Company of Indianapolis, Ind., lubricates them with heated oil and then blows off the excess oil with heated compressed air. The treatment takes place in the apparatus shown here. Immersion is effected in the square tank, which is made of sheet steel and lined bottom and sides with 3 inches of magnesia. Sixty-six General Electric strip heaters, totaling 39 kw., are clamped to the bottom and walls in six sections. An automatic thermostat regulates the temperature of the lubricant. As the chains emerge from this bath, they pass through a cylindrical tank which contains two 550-watt G-E immersion heaters and through which the air passes before it reaches the chains. The air line is seen extending from the wall to the top of this tank.

- A universal refinery pump —built for the handling of hot oils, distillates, bottoms, etc.
- Capacities to 700 g.p.m.
- Heads to 400 feet.
- Temperatures to 800°F.

The CAMERON PROCESS PUMP



Type FH—FL

THE MODERN REFINERY PROCESS PUMP

Solidly mounted, at water-cooled portion of casing, to heavy cradle, insuring permanent alignment, regardless of temperature.

Heavy duty ball bearings positively lubricated.

Water-jacketed stuffing boxes and oil reservoir.

Construction permitting complete dismantling of the unit without disturbing the piping or moving the driver.

Suction passages which are direct and liberal, preventing vaporization.

Write for descriptive literature.

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